E-newspaper (Second Year) Chase Issue no 024 dated 18-Nov-2015
(MATHEMATICS VALUES CHASE YEAR 01-10-2015 to 30-09-2016)

VEDIC MATHEMATICS
&
MODERN MATHEMATICS

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COURSE 05 PART – 2
CREATOR SPACE
(4-SPACE)
Fourth Week : Day 3

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Let us first revisit MA / M. Sc (mathematics courses of different universities of India and top universities of the world

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Maharishi Dayanand University Rohtak, India

MASTER OF SCIENCE (MATHEMATICS)
TWO YEAR PROGRAMME (ANNUAL)

First Year (Previous)
Paper Nomenclature External Internal
DEMMTH-101 Advanced Abstract Algebra 70 30
DEMMTH-102 Real Analysis 70 30
DEMMTH-103 Topology 70 30
DEMMTH-104 Programming in C 70 30
DEMMTH-105 Differential Equations 70 30

Second Year (Final)
Paper Nomenclature External Internal
DEMMTH-201 Integration theory and Functional Analysis 70 30
DEMMTH-202 Partial Differential Equations and Mechanics 70 30
DEMMTH-203 Complex Analysis 70 30
Two papers to be offered out of the following groups:-
DEMMTH-204
DEMMTH-205
Pure Group:
Advanced Discrete Mathematics
Analytical Number Theory
70
70
30
30
DEMMTH-206
DEMMTH-207
Applied Group:
Mechanics of solids
Fluid Dynamics
70
70
30
30

ADVANCE ABSTRACT ALGEBRA
PAPER DEMMTH-101
External 70
Internal 30
Note:
1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to attempt any 5 questions in all. All questions carry equal marks.
2. Internal assessment marks shall be given on the basis of marks secured by the candidate in the Descriptive Examination to be conducted by the respective study centre. Study centres are required to keep the record of the descriptive examination with them for inspection by the University. The marks of Internal Assessment must be submitted to the University before the termination of the University Examination in the concerned subjects. In the event of non receipt of the Internal Assessment Marks, the theory marks secured by the candidate shall be proportionately enhanced.

Section I (3 Questions)
Groups: Normal and subnormal series Composition series, Jordan –Holder theorem. Solvable groups. Nilpotent groups.
Conjugate elements, class equation for a finite group. Sylow p-subgroup, Sylow's theorems and their simple applications.
Survey of finite groups upto order 15.

Section II (2 Questions)
Canonical Forms: Similarity of linear transformations. Invariant subspaces Reduction to triangular form. Nilpotent transformations. Index of nilpotency. Invariants of nilpotent transformations. The primary decomposition theorem. Jordan blocks and Jordan forms.

Section III (2 Questions)
Field Theory. Algebraic and transcendental extensions. Separable and inseparable extensions. Normal extensions. Perfect fields. Finite fields. Primitive elements. Algebraically closed fields. Automorphism of extensions. Galois extensions.
Fundamental Theorem of Galois Theory. Solution of polynomial equations by radicals. Insolvability of the general equation of degree 5.

Section IV (3 Questions)
Simple modules. Schaur's Lemma. Free modules fundamental structure theorem of finitely generated modules over principal ideal domain and its applications to finitely generated abelian groups.
Noetherian and Artinian modules and rings. Hilbert basis theorem. Wedderburn Artin theorem. Uniform modules.
Primary modules and Noether-Lasker theorem.

REAL ANALYSIS
PAPER DEMMTH-102
External 70
Internal 30
Note:
1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to attempt any 5 questions in all. All questions carry equal marks.
2. Internal assessment marks shall be given on the basis of marks secured by the candidate in the Descriptive Examination to be conducted by the respective study centre. Study centres are required to keep the record of the descriptive examination with them for inspection by the University. The marks of Internal Assessment must be submitted to the

University before the termination of the University Examination in the concerned subjects. In the event of non receipt of the Internal Assessment Marks, the theory marks secured by the candidate shall be proportionately enhanced.

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Unit I

Sequence and series of functions, pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass's M test, Abel's and Dirichlefs tests for uniform convergence, uniform convergence and continuity, Uniform convergence and Riemann-Stieltjes Integration, uniform convergence and differentiation,. Weierstrass Approximation theorem, Power series, Uniqueness theorem for power series, Abel's and Tauber's theorems;

Unit II

Functions of several variables, linear transformations, derivatives in an open subset of Rn, Partial derivatives, Higher order differentials, Taylor's theorem. Explicit and Implicit functions. Implicit function theorem and inverse function theorem.

Change of variables. Extreme values of explicit and stationary values of implicit functions. Lagrange's multipliers method. Jacobian and its properties,-

Unit III

Definition and existence of Riemann-Stieltjes integral, Properties of the integral, Integration and differentiation, The fundamental theorem of calculus, Integration of vector-valued furjcfions, -Rectifiable curves. Set functions, intuitive idea of measure, Elementary properties of measure, Measurable sets and their fundamental properties. Lebesgue measure of sets of real numbers, Algebra of measurable sets; Borel sets, Equivalent formulation of measurable sets in terms of open, Closed, Fo and Gs sets, "Non measurable sets.

Unit IV

Measurable functions and their equivalent formulations. Properties of measurable functions. Approximation of measurable functions by sequences of simple functions, Measurable functions as nearly continuous functions, Egoroff s theorem, Lusin's theorem, Convergence in measure and F Hiesz theorem for convergence in measure. Almost uniform convergence.

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 Reimann integral,- Bounded - convergence theorem, Lebesgue theorem regarding points of discontinuities of Riemafm:integrable. functions, Integral of non-negative functions, Fatou's Lemma, Monotone convergence-" Theorem, Geaeral Lebesgue Integral, Lebesgue convergence theorem.

Unit V

Vrtale's covering Lemma, Differentiation of monotonic functions, Functions of bounded variation and its representation as difference of monotonic functions, Differentiation of Indefinite Integral, Fundamental Theorem of Calculus, Absolutely continuous functions and their properties.

L spaces, convex functions, Jensen's inequalities, Measure space, Generalized Fatun, Lemma, Measure and outer measure, Extension of a measure, caratheodory Extension Theorem.

TOPOLOGY
PAPER DEMMTH-103
External 70
Internal 30
Note:
1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to
attempt any 5 questions in all. All questions carry equal marks.
2. Internal assessment marks shall be given on the basis of marks secured by the candidate in the Descriptive Examination
to be conducted by the respective study centre. Study centres are required to keep the record of the descriptive
examination with them for inspection by the University. The marks of Internal Assessment must be submitted to the
University before the termination of the University Examination in the concerned subjects. In the event of non receipt
of the Internal Assessment Marks, the theory marks secured by the candidate shall be proportionately enhanced.

Unit-I
Definition and examples of topological spaces, closed sets and closure, dense subsets. "Neighbourhoods interior Exterior and
boundary operations, Accumulation points and Derived sets. Bases and subbase. Subspacesand relative topology. Alternative
method of defining a topology in terms of Kuratowski closure operator and neighbourhood systems. Continuous functions
and homoemorphisms. Connected spaces. Connectedness on the real time. Components, Locally connected spaces,

Unit-II
Compactness, continuous functions and compact sets. Basic properties of compactness and finite intersection property.
Sequentially and countably compact sets, Local compactness and one point compactification.
Separation axioms TQ, T, and T2 spaces, Their characterization and basic properties, Convergence on To spaceJirst and
second countable spaces, Lindelof s Theorems, Separable spaces and separability.

Unit-III
Regular and normal spaces, Urysohn's Lemma and Tietze Extension Theorem, T3 and T4 spaces, Complete regularity and
complete normality, *T/A* and Ts spaces.
Embedding and Metrization. Embedding Lemma and Tychonoff embedding Urysohn's Metrization Theorem.

Unit-IV
Product topological spaces, Projection mapppings, Tychonoff product topology in terms of standard subbases and its
characterization, Separation axioms and product spaces, Connectedness, locally connectedness and Com-pactness of product spaces. Product space as first axiom space.
Nets and filters. Topology and convergence of nets. Hausdorffhess and nets. Compactness and nets. Filters and their
convergence. Canonical way of converting nets to filters and vice-versa, ultra filters and compactness. Stone-Cech
compactification.

Unit-V
Homotopy of paths, Fundamental group, Covering spaces, The fundamental group of the circle and fundamental theorem of
algebra.
Covering of aspace, local finiteness, paracompact spaces, Mchaell theorem on

characterization of paracompactness in regular space, Paracompactness as normal, Nagata-SmirnovMetrization theorem.

PROGRAMMING IN C (THEORY)
PAPER DEMMTH-104
External 70
Internal 30
Note:
1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to
attempt any 5 questions in all. All questions carry equal marks.
2. Internal assessment marks shall be given on the basis of marks secured by the candidate in the Descriptive Examination
to be conducted by the respective study centre. Study centres are required to keep the record of the descriptive
examination with them for inspection by the University. The marks of Internal Assessment must be submitted to the
University before the termination of the University Examination in the concerned subjects. In the event of non receipt
of the Internal Assessment Marks, the theory marks secured by the candidate shall be proportionately enhanced.

Unit I
An overview of programming. Programming language, Classification. C Essentials-Program Development. Functions. Anatomy
of a C function. Variables and Constant. Expressions. Assignment Statements. Formatting Source Files. Continuation Character.
The Preprocessor. Scalar Data Types-Declarations, Different Types of Integers. Different kinds of Integer Constants. Fioating-
Point Types. Initialization. Mixing Types. Explicit Conversions—Casts. Enumeration Types. The Void Data Type, Typedefs.
Finding the Address of an object. Pointers.
Control Flow-Conditional Branching. The Switch Statement. Looping. Nested Loops. The break and continue State-ments. The goto statement. Infinite Loops.

Unit II
Operators and Expressions — Precedence and Associativity. Unary Plus and Minus operators. Binary Arithmetic Operators.
Arithmetic Assignment Operators. Increment and Decrement Operators. Comma Operator. Relational Operators. Logical
Operators. Bit- Manipulation Operators. Bitwise Assignment Operators. Cast Operator. Size of Operators. Conditional Operators.
Memory Operators.

Unit III (2 Questions)
Arrays and Pointers — Declaring an Array. Arrays and Memory, Initializing Arrays, Encryption and Decryption. Pointer
Arithmetic. Passing Pointers as Function Arguments. Accessing Array Elements through Pointers. Passing Arrays as Function
Arguments. Sorting Algorithms. Strings. Multidimensional Arrays. Arrays of Pointers. Pointers to Pointers.

Unit IV
Strong Classes — Fixed vs. Automatic Duration. Scope. Global variables. The register Specifier. ANSI rules for the syntax
and Semantics of the storage - class keywords. Dynamic Memory Allocation.
Structures and Unions-Structures. Linked Lists. Unions. Enum Declarations.
Functions - Passing Arguments. Declarations and Calls. Pointers to Functions. Recursion. The main () Function.
Complex Declarations.

UnitV

The C Preprocessor-Macro Substitution. Conditional Compilation. Include Facility. Line Control.

Input and Output-Streams, Buffering. The <Stdio. H> header File. Error Handling. Opening and Closing a File. Reading and Writing Data/Selecting an I/O Method. Unbuffered I/O Random Access. The standard library for input/output.

DIFFERENTIAL EQUATIONS
PAPER DEMMTH-105
External 70
Internal 30

Note:

1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to attempt any 5 questions in all. All questions carry equal marks.
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Section I (3 Questions)

Linear integral equations, some basic identities, initial value problems reduced to Volterra integral equations, Methods of successive substitutions and successive approximation to solve Volterra integral equations of second kind. Iterated kernels and Neumann series for Volterra equations. Resolvent kernel as a series in l, Laplace transform method for a difference kernel, Solution of a Volterra integral equation of the first kind.

Boundary value problems reduced to Fredholm integral equations, methods of successive approximation and successive substitutions to solve Fredholm equations of second kind. Iterated kernels and Neumann series for Fredholm equations.

Resolvent kernel as a sum of series. Fredholm resolvent kernel as a ratio of two series. Fredholm equations with separable kernels, approximation of a kernel by a separable kernel, Fredholm Alternative.

Green's function, use of method of variation of parameters to construct the Green's function for a nonhomogeneous linear second order BVP, Basic four properties of the Green's function, Alternate procedure for construction of the Green's function by using its basic four properties. Reduction of a BVP to a Fredholm integral equation with kernel as Green's function, Hilbert-Schmidt theory for symmetric kernels. (Relevant topics from Jerri's book).

Section II (3 Questions)

ε-approximate solution, Cauchy-Euler construction of an ε-approximate solution, Equicontinuous family of functions, Ascoli-Arzela lemma, Cauchy-Peano existence theorem.

Uniqueness of solutions, Lipschitz condition, Picard-Lindelof existence and uniqueness theorem for $\frac{dy}{dt} = f(t,y)$, solution of initial-value problems by Picard method.

Sturm-Liouville BVPs, Sturms separation and comparison theorems, Lagrange's identity and Green's formula for

second order differential equatins, properties of eigenvalues and eigenfunctions, Pruffer transformation, adjoint systems,
self-adjoint equations of second order.
Linear systems, Matrix method for homogeneous first order system of linear differential equations, fundamental set
and fundamental matrix, Wronskian of a system, Method of variation of constants for a nonhomogeneous system with
constant coefficients, nth order differential equation equivalent to a first order system (Relevant topics from the books by
Ross, and Coddington and Levinson).

Section III (2 Questions)
Nonlinear differential system, plane autonomous systems and critical points, classification of critical points – rotation points,
foci, nodes, saddle points. Stability, asymptotical stability and unstability of critical points, almost linear systems, Liapunov
function and Liapunov's method to determine stability for nonlinear systems.
Periodic solutions and Floquet theory for periodic systems, limit cycles, Bendixson non-existence theorem, Poincare-
Bendixson theorem (Statement only), index of a critical point. (Relevant topics from the books by Ross, and Coddington and
Levinson).

Section IV (2 Questions)
Motivating problems of calculus of variations, shortest distance, minimum surface of revolution, Branchistochrone problem,
isoperimetric problem, geodesic. Fundamental lemma of calculus of variations, Euler's equation for one dependant function
and its generalization to 'n' dependant functions and to higher order derivatives, conditional extremum under geometric constraints and under integral constraints (Relevant topics from the book by Gelfand and Fomin).

M.Sc. (Final)
INTEGRATION THEORY AND FUNCTIONAL ANALYSIS
PAPER DEMMTH-201
External 70
Internal 30
Note:
1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to
attempt any 5 questions in all. All questions carry equal marks.
2. Internal assessment marks shall be given on the basis of marks secured by the candidate in the Descriptive Examination
to be conducted by the respective study centre. Study centres are required to keep the record of the descriptive
examination with them for inspection by the University. The marks of Internal Assessment must be submitted to the
University before the termination of the University Examination in the concerned subjects. In the event of non receipt
of the Internal Assessment Marks, the theory marks secured by the candidate shall be proportionately enhanced.

Unit I
Signed measure, Hahn decomposition theorem, Jordan decomposition theorem, Mutually singular measure, Radon-i Nikodym
theorem. Lebesgue decomposition, Lebesgue-Stieltjes integral, Product measures, Fubini's theorem.!
Baire sets, Baire measure, Continuous functions with compact support, Regularity of measures on locally compact support,
Riesz-Markoff theorem.

Unit II

Normed linear spaces, Metric on normed linear spaces, Holder's and Minkowski's inequality, Completeness of quotient spaces of normed linear spaces. Completeness of /, *If,* Rn, Cn and C [a, b]. Bounded linear transformation. Equivalent formulation of continuity. Spaces of bounded linear transformations, Continuous linear functional, Conjugate spaces, Hahn-Banach extension theorem (Real and Complex form), Riesz Representation theorem for bounded linear functionate on *V* and C[a,b].

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Unit III

Second conjugate spaces, Reflexive spaces, Uniform boundedness principle and its consequences, Open mapping theorem and its application, projections, Closed Graph theorem, Equivalent norms, weak and strong convergence, their equivalence in finite dimensional spaces.

Unit IV

Compact operations and its relation with continuous operator. Compactness of linear transformation on a fin its dimensional space, properties of compact operators, Compactness of the limit of the sequence of compae operators. The closed range theorem.

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

Unit V

Orthonormal sets, Besseil's inequality, ParsevaPs identity, Conjugate of Hilbert space, Riesz representatioi theorem in Hilbert spaces. Adjoint of an opertor on a Hilbert space, Reflexivity of Hilbert space, Self-adjoin operator, Positive operator, Normal and unitary operators, Projections on Hilbert space, Spectral theorem oi finite dimensional spaces, Lax-Milgiam theorem.

PARTIAL DIFFERENTIAL EQUATIONS AND MECHANICS
PAPER DEMMTH-202
External 70
Internal 30

Note:

1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to attempt any 5 questions in all. All questions carry equal marks.
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Section-I

Solution of three-dimensional Laplace equation by using the method of separation of variables in terms of Cartesian, cylindrical and spherical coordinates. Method of separation of variables to solve three-dimensional wave equation in Cartesian and spherical coordinates. Use of the method of separation of variables to find steady- state temperature in a rectangular plate, in

a disk, in a bar with ends at different temperatures, in a semi-infinite bar, in an infinite plate, in a semi-infinite bar, in an infinite cylinder, in a solid sphere (Relevant topics from the books by Sneddon, and O'Neil).

Section-II

Kinematics of a rigid body rotating about a fixed point, Euler's theorem, general rigid body motion as a screw motion, moving
Coordinate system - rectilinear moving frame, rotating frame of reference, rotating earth.
Moments and products of inertia, Angular momentum of a rigid body, principal axes and principal moment of inertia of
a rigid body, kinetic energy of a rigid body rotating about a fixed point, Momental ellipsoid and equimomental systems,
coplanar mass distributions, general motion of a rigid body.
Two- dimensional rigid body dynamics – problems illustrating the laws of motion and impulsive motion.
(Relevant topics from the book of Chorlton).

Section-III

D'Alembert's principle : Constraints, 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, 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, *i* *q*□), Lagrange's equations for potential forces, generalized momenta pi , Hamiltonian variable and Hamiltonian function H(t, qi, pi), Donkin's theorem, ignorable coordinates.

Section-IV

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.
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 variables
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 transformations.

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. Sneddon, I.N., Elements of Partial Differential Equations, McGraw Hill, New York.
6. O'Neil, Peter V., Advanced Engineering Mathematics, ITP.
7. F. Chorlton, Textbook of Dynamics, CBS Publishers, New Delhi.
8. H.F. Weinberger, A First Course in Partial Differential Equations, John Wiley & Sons, 1965.
9. K. Sankra Rao, Classical Mechanics, Prentice Hall of India, 2005.
10. M.R. Speigal, Theoretical Mechanics, Schaum Outline Series.

COMPLEX ANALYSIS
PAPER DEMMTH-203
External 70
Internal 30
Note:
1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to attempt any 5 questions in all. All questions carry equal marks.
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Unit I
Analysis functions, Cauchy-Riemann equation in cartesian and polar coordinates. Complex integration. ' Cauchy-Goursat Theorem. Cauchy's integral formula. Higher order derivatives. Morera's Theorem. Cauchy's inequality and Liouville's theorem, The fundamental theorem of algebra. Taylor's theorem.

Unit-II
Isolated singularities. Meromorphic functions. Maximum modulus principle. Schwarz lemma. Laurent's series. The argument principle. Rouche's theorem. Inverse function theorem.
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Residues. Cauchy's residue theorem. Evaluation of integrals. Branches of many valued functions with special reference to arg z, log z and *zl*.

Unit-III
Bilinear transformations, their properties and classifications. Definitions and examples of Conformal mappings. Space of analytic functions. Hurwitz's theorem. Montel's theorem. Riemann mapping theorem.
Weierstrass' factorisation theorem. Gammar function and its properties. Riemann Zeta function. Riemann's functional equation. Runge's theorem. Mittag-Leffler's theorem.

Unit IV
Analytic Continuation. Uniqueness of direct analytic continuation. Uniqueness of analytic continuation along a curve. Power series method of analytic continuation. Schwarz Reflection principle. Monodromy theorem and its consequences. Harmonic functions on a disk. Harnack's inequality and theorem. Dirichlet problem. Green's function.
Canonical products. Jensen's formula. Poisson-Jensen formula. Hadamard's three circles theorem.

Unit V

Order of an entire function. Exponent of Convergence. BorePs theorem. Hadamard's factorization theorem.

The range of an .analytic function. Bloch's theorem. The LittlePicard theorem. Schottky's theorem. Montel Caratheodory and the Great picard theorem.

Univalent functions. Bieberbach's conjecture (Statement only) and the "1/4 theorem.

ADVANCED DISCRETE MATHEMATICS

PAPER DEMMTH-204

External 70

Internal 30

Note:

1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to attempt any 5 questions in all. All questions carry equal marks.

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Unit I

Formal Logic: Statement, Symbolic representation, totologies, quantifiers, pradicates and validity, propositional. logic.

Semigroups and Monoids: Definitions and examples of semigroups and monoids (including those pertaining to concentration operations). Homoraorphism of semigroups and monoids, Congurence relation and quotient semigroups, sub semigropups and sub monoids, Direct products basic homomorphism theorem.

Lattices: Lattices as partially ordered sets, their properties. Lattices and algebraic systems. Sub lattices, direct products and homomorphism. Some special lattices for example complimented and distributive lattices.

Unit II

Boolean Algebra: Boolean Algebra as Lattices. Various Boolean Identities Join-irreducibie elements. Atoms and Minterms. Boolean Forms and their Equivalence. Minterm Boolean Forms, Sum of Products Canonical Forms. Minimization of Boolean Functions. Applications of Boolean Algebra to Switching Theory (using AND, OR and NOT gates). The Karnaugh Map method.

Unit III

Graph Theory - Definition of (undirected) Graphs, Paths, Circuits, Cycles and Subgroups. Induced Subgraphs. Degree of a vertex. Connnectivity. Planar Graphs and their properties. Trees, Duler's Formula for connected Planar Graphs, Complete and Complete Bipartite Graphs. Kurtowski's Theorem (statement only) and its use.' Spanning Trees. Cut-sets. Fundamental

Cut-sets and Cycles/Minima! Spanning Trees and Kruskal's Algorithum. Matrix Representations of Graphs. EuSer's Theorem on the Existence of Eulerian Paths and Circuits, Directed Graphs. Indegree and Outdegree of a Vertex. Weighted undirected Graphs. Dijkstra's Algorithm. Strong Con-nectivity & Warshall's Algorithm. Directed Trees. Search Trees. Tree Traversals.

Unit IV

Introductory Computability Theory - 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 Ma-chines.

Unit V

Grammar and Languages — Phrase Structure Grammars. Rewriting Rules. Derivations Sentential Forms. Language generated by Grammar. Regular, Context Free, and Context Sensitive Grammar and Languages. Regular sets, Regular Expressions and the Pumping Lemma, Kleene's Theorem. Notions of Syntax Analysis. Polish Notations. Conversion of Infix Expressions to Polish Notations. The Reverse Polish Notation.

ANALYTICAL NUMBER THEORY
PAPER DEMMTH-205
External 70
Internal 30

Note:

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Unit I

Primes in certain arithmetical progressions, Fermat numbers and Mersenne numbers. Farey series and some results concerning Fary series. Apprbximtion of irrational numbers by rations. Hurwitz's theorem irrationality of e and n. The series of Fibonocci and Lucas. System of linear congruences Chinese Remainder Theorem. Congruence to prime power modulus.

Unit II

Quadratic residues and non-residues. Legender's Symbol. Gauss Lemma and its applications. Quadratic Law of Reciprocity jacobi's Symbol. The arithmetic in Z . The group Un. Primitive roots. The group Up n (p-odd) and U2 n, The existence of primitive roots. The group of quadratic residues. Quadratic residues for prime power moduli and arbitrary moduli.

Unit III

Riemann Zeta Function E,(s) and its convergence. Application to prime numbers. \ (s) as Eider's product. Evaluation of £,(2) and q(2k). Dirichlet series with simple properties. Dirichlet series as analytic function and its derivative. Euiers products. Introduction to modular forms.

Unit IV

Diophantine equations, x2 + *y2 = z2* and x4 + y4 = z4. The representation of number by two or four squares. Waring's problem.

Four square theorem. The number g(k) & G(k). Lower bounds for g(k) & G(k).
Algebraic number and Integers ; Gaussian integers and its properties. Primes and fundamental theorem in the ring of Gaussian integers. Integers and fundamental theorem in Q (w) where w3 = 1, algebraic fields. Primitive polynomials. The general quadratic field Q(^m), Units of Q (^2). Fields in which fundamental theorem is false. Real and complex Euclidean fields.
Fermat" theorem in the ring of Gaussian integers. Primes of Q(2) and Q(5). Luca" test for the prmality of the Mersenne number.

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Unit V
Arithmetical function (j)(n), u,(n), d(n) and a(n) Mobius inversion formulae. Perfect numbers. Order and average order of d(n), <|>(n). The functions $(x), vy(x) and A(x). Betrand postulate. Sum p""1 and product 1 +p"'. Merten's theorem
Selberg's theorem. Prime number Theorem.

MECHANICS OF SOLIDS
PAPER DEMMTH-206
External 70
Internal 30
Note:
1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to attempt any 5 questions in all. All questions carry equal marks.
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Unit I
Analysis of Stein: Affine transformation. Infinite simal affine deformation. Geometrical interpretation of the componentsdsirain.
Strain quaciric of Cauchy. Principal strains and invariants. Genera! infinitesimal deforma-i tion. Saint-VeMBt's equations of Compatibility. Finite deformations.

Unit II
Equations ofHasticity: Generalized Hooke's law. Homogeneous isotropic media. Elasticity moduli for isotro-1 pic media.
Eqsiibrium and dynamic equations for an isotropic elastic solid. Strain energy function and its con-nection withlisike's law.
Uniquness of solution. Beltrami-Micheli compatibility equations. Saint-Venant's prin-: ciple.

Unit III
Two - dimesm&al Problems: Plane stress. Generalized plane stress. Airy stress function. General solution of Biharmonkequation,
Stresses and displacements in terms of complex potentials. Simple problems. Stress function appnpiate to problems of plane stress. Problems of semi-infinite solids with displacements or stresses i prescribed onfc plane boundary.

Unit IV
Torsional Pi^lem: Torsion of cylindrical bars. Tortional rigidity. Torsion and stress functions. Lines of shear-ing stress.
Sinfteproblems related to circle, elipse and equilateral triangle.

Variationa) IHslSiods: Theorems of minimum potential energy. Theorems of minimum complementary energy. Reciprocal ths^em of Betti and Rayleigh. Deflection of elastic string, central line of a beam and elastic mem-brane. Torsionrfcylinders.
Variational problem related to biharmonic equation. Solution of Euier's equation by Ritz, Galerkinaed Kantorovich methods.

Unit V
Elastic Waves Propagation of waves in an isotropic elastic solid medium. Waves of dilatation and distortion Plane waves.
Elastic surface waves such as Rayleigh and Love waves.

FLUID DYNAMICS
PAPER DEMMTH-207
External 70
Internal 30
Note:
1. Examiner is required to set 10 questions covering whole syllabus of the paper and the candidates are required to
attempt any 5 questions in all. All questions carry equal marks.
380
2. Internal assessment marks shall be given on the basis of marks secured by the candidate in the Descriptive Examination
to be conducted by the respective study centre. Study centres are required to keep the record of the descriptive
examination with them for inspection by the University. The marks of Internal Assessment must be submitted to the
University before the termination of the University Examination in the concerned subjects. In the event of non receipt
of the Internal Assessment Marks, the theory marks secured by the candidate shall be proportionately enhanced.
UNIT I
Kinematics — Lagrangian and Eulerian methods. Equation of continuity. Boundary surface. Stream lines. Path lines and streak lines. Velocity potential. Irrotational and rotational motions. Vortex lines.
Equations of Motion—Lagrange's and Euler's equations ofmotion. Bernoulli's theorem. Equation of motion byfiux
method. Equations referred to moving axes Impulsive actions. Stream function.
Irrotational motion in two-dimensions. Complex velocity potential. Sources, sinks, doublets and their images. Conformal
mapping, Milne-Thomson circle theorem. Two-dimensional irrotational motion produced by motion of circular, co-axial and
elliptic cylinders in an infinite mass of liquid. Kinetic energy of liquid. Theorem of Blasius. Motion of a sphere through a liquid
at rest at infinity. Liquid streaming past a fixed sphere. Equation ofmotion of a sphere. Stoke's stream function.

UNIT II
Vortex motion and its elementary properties. Kelvin's proof of permance. Motions due to circular and rectilinear vertices.
Wave motion in a gas. Speed of Sound. Equation of motion of a gas. Subsonic, sonic and supersonic flows of a gass.
Isentropic gas flows. Flow through a nozzle. Normal and oblique shocks.

UN1T III
Stress components in a real fluid. Relations between rectangular components of stress. Connection between stresses and
gradients of velocity. Navier-stoke's equations ofmotion. Plane Poiseuille and Couette flows between two parallel plates.
Theory of Lubrication. Flow through tubes of uniform cross section in form of circle, annulus, ellipse and equilateral triangle
under constant pressure gradient. Unsteady flow over a flat plate.

UNTT IV

Dynamical similarity. Buckingham p-theorem. Reynolds number. Prandt's boundary layer. Boundary layer equations in twodimensions. Blasius solution. Boundary-layer thickness. Displacement thickness. Karman integral conditions. Separations of boundary layer flow.

II

Punjab University, Chandigarh, India

M.Sc. (Pass Course) in Mathematics

SEMESTER I (November/December, 2012)

MATH-601S : Real Analysis-I
MATH-602S : Algebra -I
MATH-603S : Differential Equations
MATH-604S : Complex Analysis-I
MATH-605S : Number Theory-I

SEMESTER II (April/May, 2013)

MATH-621S : Real Analysis-II
MATH-622S : Algebra -II
MATH-623S : Vector Analysis and Mechanics
MATH-624S : Complex Analysis-II
MATH-625S : Number Theory–II

SEMESTER III (November/December, 2012)

MATH-617S : Field Theory (Compulsory Course)
MATH-618S : Topology (Compulsory Course)
MATH-661S : Probability and Mathematical Statistics-I
MATH-672S : Computational Techniques-I
MATH-673S : Differential Geometry-I
MATH-674S : Elasticity -I
MATH-675S : Special Functions
MATH-676S : Fluid Mechanics-I
MATH-678S : Linear Programming
MATH-680S : Geometry of Numbers-I
2 M.SC. MATHEMATICS (SEMESTER SYSTEM)

SEMESTER IV (April/May, 2013)

MATH-637S : Linear Algebra (Compulsory Course)
MATH-638S : Functional Analysis (Compulsory Course)
MATH-681S : Probability and Mathematical Statistics-II
MATH-692S : Computational Techniques-II
MATH-693S : Differential Geometry-II
MATH-694S : Elasticity -II
MATH-695S : Integral Transforms and Their Applications
MATH-696S : Fluid Mechanics-II
MATH-698S : Non-Linear Programming
MATH-700S : Geometry of Numbers-II
M.SC. MATHEMATICS (SEMESTER SYSTEM) 3

SEMESTER-I

MATH 601S : Real Analysis-I
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1**.** The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No. 1 is compulsory and will consist of short answer type questions covering
the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

(i) **Basic Topology :** Finite, countable and uncountable sets. Metric spaces, compact sets. Perfect sets.
Connected sets.

(ii) **Sequences and series :** Convergent sequences (in metric spaces). Subsequences. Cauchy
sequences. Upper and lower limits of a sequence of real numbers. Riemann's Theorem on
Rearrangements of series of real and complex numbers.

(iii) **Continuity :** Limits of functions (in metric spaces). Continuous functions. Continuity and
compactness. Continuity and connectedness. Monotonic functions.

UNIT- II

(iv) **The Riemann-Stieltjes integral**: Definition and existence of the Riemann-Stieltjes integral.
Properties of the integral. Integration of vector-valued functions. Rectifiable curves.

(v) **Sequences and series of functions**: Problem of interchange of limit processes for sequences of
functions. Uniform convergence. Uniform convergence and continuity. Uniform convergence and
integration. Uniform convergence and differentiation. Equicontinuous families of functions, The
Stone-Weierstrass theorem.

Scope

As in relevant sections of Chapters 2,3,4,6,7 of the book at Sr. No. 6 in the list of references.

References:

1. Apostol, Tom, Mathematical Analysis - A Modern Approach to Advanced Calculus, Addison -
Wesley Publishing Company, Inc. 1987. (Indian Edition by Narosa Publishing House New Delhi
also available).
2. Bromwich, T.J.I.A., An Introduction to the Theory of Infinite Series. Second edition (Revised with
the assistance of T. M. Mac Robert). Macmillan and Co. Ltd., New York, 1955.
3. Goldberg, R.R., Methods of Real Analysis, Oxford and IHB Publishing Company, New Delhi.
4. Knopp, K., Theory and Applications of Infinite Series, Blackie and Sons Ltd. London and
Glasgow Second Edition, 1951 (Reprinted 1957).
5. Malik, S.C., Mathematical Analysis, Wiley Eastern, New Delhi, 1984.
6. Rudin, Walter, Principles of Mathematical Analysis, Third Edition (International Student Edition)
McGraw-Hill Inc., 1983.
7. Shanti Narayan, A Course of Mathematical Analysis, S. Chand and Co. Ltd., New Delhi, Twelfth
Revised Edition, 1986.
8. Titchmarsh, E.C., The Theory of Functions, Second Edition, The English Language Book Society and
Oxford University Press, 1961.

Math 602S: Algebra- I
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks

Time : 3 hrs.

Note : 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT- I

Review of basic concepts of groups with emphasis on exercises. Permutation groups, Even and odd permutations, Conjugacy classes of permutations, Alternating groups, Simplicity of An, n > 4. Cayley's Theorem, Direct products, Fundamental Theorem for finite abelian groups, Sylow theorems and their applications, Finite Simple groups [Scope as in chapters 2-4 Modern Algebra by Surjeet Singh and Qazi Zameerudin, Eighth Edition and chapters 11, 24, 25 of Contemporary Abstract Algebra by Gallian, Fourth Edition]

UNIT-II

Survey of some finite groups, Groups of order p^2, pq (p and q primes). Solvable groups, Normal and subnormal series, composition series, the theorems of Schreier and Jordan Holder [Scope as in Chapters 6 of Modern Algebra by Surjeet Singh and Qazi Zameerudin, Eighth Edition and Chapter 7 of Algebra, Vol. I by Luther and Passi].

Review of basic concepts of rings with emphasis on exercises. Polynomial rings, formal power series rings, matrix rings, the ring of Guassian Integers. [Scope as in Chapters 7, 8 and 9 of Modern Algebra by Surjeet Singh and Qazi Zameerudin, Eighth Edition , 2006].

References:

1. Luther I.S. and Passi I.B.S., *Algebra,* Vol.I & II, Narosa Publishing House, New Delhi.

2. Gallian J.A, *Contemporary Abstract Algebra,* Narosa Publishing House, New Delhi.

3. Singh Surjeet and Qazi Zameeruddin, *Modern Algebra,* Vikas Publishing House, New Delhi (8th Edition) 2006.

4. Herstein I.N., *Topics in Algebra* (Second Edition), Wiley Eastern Limited, New Delhi.

5. Musili C, *Rings and Modules* (Second Revised Edition), Narosa Publishing House, New Delhi, 1994.

6. Artin M, *Algebra*, Prentice Hall of India, New Delhi, 1994.

7. Bhattacharya P.B.; Jain S.K.; and Nagpal S.R., *Basic Abstract Algebra,* Cambridge University Press, New Delhi.

8. Burnside W, *The Theory of Groups of Finite Order (2nd Ed.),* Dover, New York, 1955.

9. Fraleigh J.B., *A First Course in Abstract Algebra,* Narosa Publishing House, New Delhi.

10. Hartley B. and Hawkes T.O., *Rings, Modules and Linear Algebra,* Chapman and Hall.

11. Hungerford T.W., *Algebra,* Springer 1974.

Math 603S: Differential Equations
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two
questions from each Unit.
4. All questions carry equal marks.

UNIT-I
Differential Equations
Existence and uniqueness of solution of first order equations. Boundary value problems and Strum-
Liouville theory. ODE in more than 2-variables.
[Scope as in Chapter V of the book 'An introduction to Ordinary Differential Equations' by E.A.Coddington
and Chapters X & XI of the book 'Elementary Differential Equations and Boundary Value Problems' by W.E.Boyce and R.C.Diprima.]

UNIT-II
Partial differential equations of first order.
Partial differential equations of higher order with constant coefficients.
Partial differential equations of second order and their classification.
[Scope as in Chapters I, II & III of the book 'Elements of Partial Differential Equations' by I.N.Sneddon].

References:

1. Coddington E.A., An Introduction to Ordinary Differential Equations. Ch. V., Prentice Hall of India
Pvt. Ltd., New Delhi 1987.
2. Boyce W.E and Diprima, R.C., Elementary Differential Equations and Boundary Value Problems.
Ch. X, XI, 4th Edition, John Wiley and Sons, USA.
3. Sneddon I.N : Elements of Partial Differential Equations, Ch. I, II, III, McGraw Hill, 1957.
4. Tyn Mying-U : Differential Equations of Mathematical Physics.

Math 604S : Complex Analysis-I
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I
Complex plane, geometric representation of complex numbers, joint equation of circle and straight line,
stereographic projection and the spherical representation of the extended complex plane. Topology on the

complex plane, connected and simply connected sets. Complex valued functions and their continuity. Curves, connectivity through polygonal lines.Analytic functions, Cauchy-Riemann equations, Harmonic functions and Harmonic conjugates.Power series, exponential and trigonometric functions, arg z, log z, a_z and their continuous branches.
(Scope as in "Foundations of Complex Analysis" by Ponnusamy S., Chapter 1, (§1.1-§ 1.5),Chapter 2 (§ 2.2, §2.3), Chapter 3, (§3.1-§3.5), Chapter 4, (§4.9).)

UNIT-II

Complex Integration, line integral, Cauchy's theorem for a rectangle, Cauchy's theorem in a disc, index of a point with respect to a closed curve, Cauchy's integral formula, Higher derivatives, Morrera's theorem, Liouville's theorem, fundamental theorem of Algebra. The general form of Cauchy's theorem.
(Scope as in "Foundations of Complex Analysis" by Ponnusamy S., Chapter 4, (§4.1-§ 4.8), Chapter 6 (§ 6.4, §6.6)."Complex Analysis" by L/ V. Ahlfors, Chapter 4 (§1, 2, 4.1 to 4.5and §5.1)
8 M.SC. MATHEMATICS (SEMESTER SYSTEM)

References:

1. Shanti Narayan, Theory of Functions of a Complex Variable, S. Chand and Co. (Seventh Edition, 1986).
2. Ahlfors, L.V., Complex Analysis, Third Edition (International student edition) McGraw-Hill International Book Company.
3. Conway, J.B., Function of One Complex Variable, Second Edition, 1978. Corr 4th Print 1986 Graduate Texts, Springer-Verlag, Indian edition by Narosa Publishing House, New Delhi.
4. Copson, E. T., An Introduction to the Theory of Functions of a Complex Variable, The English Language Book Society and Oxford University Press, 1985.
5. Knopp, K., Theory of Functions (Translated by F. Bagemite) in Two Volumes, Dover Publications, Inc. New York, 1945, 1947.
6. Pati, T., Functions of a Complex Variable, Allahabad, Pothishala, 1971.
7. Saks, S and Zygmund, A., Analytic Functions (Translated by E. J. Scott) Poland, Warszawa. 1952.
8. Silverman, R., Introductory Complex Analysis, Prentice-Hall Inc. Englewood Cliffs, N. J., 1967.
9. Deshpande, J. V., Complex Analysis, Tata McGraw-Hill Publishing Company Ltd., 1989.
10. Tichmarsh, E.C., The Theory of Functions, The English Language Book Society and Oxford University Press, Second Edition, 1961.
11. Tutschke Wolfgang and Vasudeva, Harkrishan L., An Introduction to Complex Analysis, Classical and Modern Approaches, Chapman and Hall/CRC, 2005.
12. Ponnusamy S., Foundations of Complex Analysis, Second Edition Narosa Publishing House, New Delhi, 2005

MATH-605S : **Number Theory-1**
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.
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UNIT-I
Divisibility, Greatest common divisor, Euclidean Algorithm, The Fundamental Theorem of arithmetic,
congruences, Special divisibility tests, Chinese remainder theorem, Fermat's little theorem, Wilson's
theorem, residue classes and reduced residue classes, Euler's theorem, An Application to cryptography,
Arithmetic functions □ (n), d(n), □(n), □(n), Mobius inversion Formula, the greatest integer function,
perfect numbers, Mersenne primes and Fermat numbers.

UNIT-II
Primitive roots and indices. Quadratic residues, Legendre symbol, Quadratic reciprocity law, Jacobi
symbol, Binary quadratic forms and their reduction, sums of two and four squares, positive definite binary
quadratic forms, Diophantine equations $ax+by=c$, $x^2+y^2=z^2$, $x^4+y^4=z^2$.
[Scope as in Chapters 2-8, 10 of 'Elementary Number Theory', 2nd Edition, by David M. Burton, Chapters
3, 5(sections 5.1, 5.3, 5.4) of 'Introduction to the Theory of Numbers', 5th Edition, by Niven, Zuckerman &
Montgomery.]

References:
1. David, M. Burton, Elementary Number Theory, 2nd Edition (UBS Publishers).
2. Niven, Zuckerman & Montgomery, Introduction to Theory of Numbers, 5th Edition (John Wiley &
Sons).
3. Davenpart H., Higher Arithmetic (Camb. Univ. Press)
4. Hardy & Wright, Number Theory (Oxford Univ. Press).
5. Dence, J. B. & Dence T. P., Elements of the Theory of Numbers (Academic Press).
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Semester-II

MATH-621S : Real Analysis-II
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I
(i) **Differentiation**: Differentiation of vector-valued functions.

(ii) **Functions of several variables:** The space of linear transformations on R_n to R_m as a metric
space. Differentiation of a vector-valued function of several variables. The inverse function theorem.
The implicit function theorem.
(iii) **Lebesgue measure**: Introduction. Outer measure. Measurable sets and Lebesgue measure. A nonmeasurable
set. Measurable functions. Littlewood's three principles.

UNIT-II
(iv) **The Lebesgue integral:** The Lebesgue integral of a bounded function over a set of finite measure.
The integral of a non-negative function. The general Lebesgue integral. Convergence in measure.
(v) **Differentiation and Integration**: Differentiation of monotone functions. Differentiation of an
integral. Absolute continuity. Convex functions.
Scope
(i) For items (i) & (ii) as in relevant sections of Chapters 5 & 9 of the book at Sr. No. 5 in the list of
references.
(ii) For items (iii) to (v) as in relevant sections of Chapters 3 to 5 of the book at Sr. No. 4 of references.
M.SC. MATHEMATICS (SEMESTER SYSTEM) 11

References:
1. Apostol, Tom, Mathematical Analysis - A Modern Approach to Advanced Calculus, Addison -
Wesley Publishing Company, Inc. 1987. (Indian Edition by Narosa Publishing House New Delhi
also available).
2. Goldberg, R.R., Methods of Real Analysis, Oxford and IHB Publishing Company, New Delhi.
3. Malik, S.C., Mathematical Analysis, Wiley Eastern, New Delhi, 1984.
4. Royden, H.L., Real Analysis, Macmillan and Co. Ltd. New York, Second Edition 1968, New
York, Third Edition 2009.
5. Rudin, Walter, Principles of Mathematical Analysis, Third Edition (International Student Edition)
McGraw-Hill Inc. 1983.

Math 622S: Algebra II
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT- I
Factorization Theory in Integral Domains, Divisibility, Unique Factorization Domain (UFD),
Principal Ideal Domain (PID), Euclidian Domain (ED) and their relationships. Noetherian and Artinian
Rings, Examples and Counter Examples, Artinian Rings without zero divisors, Nil Ideals in Artinian Rings,
Hilbert Basis Theorem. [Scope as in Chapters 10 and 15 of Modern Algebra by Surjeet Singh and Qazi

Zameerudin, Eighth Edition, 2006].

UNIT-II

Modules, Difference between Modules and Vector Spaces, Module Homomorphisms, Quotient
Module, Completely reducible or Semisimple Modules, Free Modules, Representation and Rank of Linear
Mappings, Smith normal Form over a PID, Finitely generated modules over a PID, Rational Canonical
Form, Applications to finitely generated abelian groups [Scope as in Chapters 14. 20 and 21 (Sections 1, 2,
3, 4) of Basic Abstract Algebra by P. B. Bhattacharya, S. K. Jain, and S. R. Nagpal, Cambridge University
Press, 1986].

References:

1. Luther, I.S. and Passi, I.B.S., Algebra, Vol. II & III, Narosa Publishing House, New Delhi.
2. Gallian, J. A., Contemporary Abstract Algebra, Narosa Publishing House, New Delhi.
3. Singh Surjeet and Qazi Zameeruddin, Modern Algebra, Vikas Publishing House, New Delhi
(8th Edition) 2006.
4. Herstein, I. N., Topics in Algebra (Second Edition), Wiley Eastern Limited, New Delhi.
5. Musili C, Rings and Modules (Second Revised Edition), Narosa Publishing House, New Delhi,
1994.
6. Artin, M., Algebra, Prentice Hall of India, New Delhi, 1994.
7. Bhattacharya P.B.; S.K. Jain; and S.R. Nagpal, Basic Abstract Algebra, Cambridge University
Press, New Delhi.
8. Burnside W., The Theory of Groups of Finite Order (2nd Ed.), Dover, New York, 1955.
9. Fraleigh, J.B., A First Course in Abstract Algebra, Narosa Publishing House, New Delhi.
10. Hartley, B and Hawkes T.O., Rings, Modules and Linear Algebra, Chapman and Hall.
11. Hungerford, T.W., Algebra, Springer, 1974.

Math 623S : Vector Analysis and Mechanics
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

Vectors

Scalar and vector point functions, Differentiation and integration of vectors, Gradient divergence and curl
operators, Green's and Stoke's theorems, Gauss' divergence theorem, Curvilinear co-ordinates.
[Scope as in Chapters VI & VII of the book 'A Text Book of Vector Calculus' by Shanti Narayan and J. N.

Kapur, 1996, S. Chand & Company Ltd., New Delhi.]

UNIT-II
Mechanics
Generalized co-ordinates. Lagrange's equations. Hamilton's canonical equations. Hamilton's principle of
least action. Reduction to the equivalent one body problem. The equations of motion and first integral. The
equivalent one-dimensional problem and classification of orbits. The Viral theorem. Rigid body
motion about an axis. Moving axis.
[Scope as in Chapters I-V and VIII of the book 'Classical Mechanics' by H.Goldstein, C. Poole and J. Safko,
3rd Edition, Addison Wesley (2002)].

References:
1. Weatherburn, C.E. , Advanced Vector Analysis.
2. Goldstein H., Poole, C. and Safko, J., Classical Mechanics, 3rd Edition, Addison Wesley (2002).
3. Schaum Series, Vector Analysis.
4. Shanti Narayan and J. N. Kapur, A Text Book of Vector Calculus, 1996, S. Chand & Company Ltd.,
New Delhi.

MATH 624S : Complex Analysis-II
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.
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UNIT-I
Maximum Modulus principle, Schwarz' Lemma, Taylor series and Laurent series. Singularities, Cauchy's
residue theorem. Calculus of residues, bilinear transformations. Zeros and poles of meromorphic functions,
Rouche's theorem, Argument Principle.
(Scope as in "Foundations of Complex Analysis" by Ponnusamy S., Chapter 6 (§6.1-§6.3),
Chapter 4(§4.10-§4.12), Chapter 7, Chapter 8, Chapter 9.)

UNIT-II
Definitions and examples of conformal mappings. Infinite products, Weierstrass theorem,
Mittagleffer's theorem, Canonical product, Analytic Continuation through power series (basic
ideas), Natural boundary, the Gamma function and Riemann Zeta function.
(Scope as in "Foundations of Complex Analysis" by Ponnusamy S., Chapter 5, Chapter 10 (§10.1, §10.4),
Chapter 11.)

References:
1. Shanti Narayan, Theory of Functions of a Complex Variable, S. Chand and Co. (Seventh Edition,
1986).

2. Ahlfors, L.V., Complex Analysis, Third Edition (International student edition) McGraw-Hill
International Book Company.
3. Conway, J.B., Function of One Complex Variable, Second Edition, 1978. Corr 4th Print 1986,
Graduate texts, Springer-Verlag, Indian Edition, Narosa Publishing House, New Delhi.
4. Copson, E. T., An Introduction to the Theory of Functions of a Complex Variable, The English
Language Book Society and Oxford University Press, 1985.
5. Knopp, K., Theory of Functions (translated by F Bagemite) in Two Volumes, Dover Publications,
Inc. New York 1945, 1947.
6. Pati, T., Functions of a Complex Variable, Allahabad Pothishala, 1971.
7. Saks, S., and Zygmund, A., Analytic Functions (Translated by E. J. Scott) Poland, Warszawa, 1952.
8. Silverman, R., Introductory Complex Analysis, Prentice-Hall Inc. Englewood Cliffs, N.J., 1967.
9. Deshpande, J.V., Complex Analysis, Tata McGraw-Hill Publishing Company Ltd., 1989.
10. Tichmarsh, E.C., The Theory of Functions, The English Language Book Society and Oxford
University Press, Second Edition, 1961.
11. Tutschke Wolfgang and Vasudeva, Harkrishan L., An Introduction to Complex Analysis, Classical
and Modern Approaches, Chapman and Hall/CRC, 2005.
12. S. Ponnusamy, Foundations of Complex Analysis, Second Edition, Narosa Publishing House, New
Delhi, 2005.

MATH-625S : **Number Theory-II**
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

Farey sequences, Continued fractions, Approximation of reals by rationals**,** Pell's equations, Minkowski's
theorem in Geometry of Numbers and its applications.
[Scope as in 6 & 7 of 'Introduction to the Theory of Numbers', 5th Edition, by Niven, Zuckerman &
Montgomery.]

UNIT-II

Partitions [Scope as in Chapter 10 of 'Theory of Numbers', 5th Edition, by Niven, Zuckerman &
Montgomery], Order of magnitude and average order of arithmetic functions, Euler summation formula,
Abel's Identity, Elementary results on distribution of primes.
[Scope as in Chapters 3 & 4 of 'Introduction to Analytic Number Theory' by T. M. Apostol.]

References:

1. David, M. Burton , Elementary Number Theory, 2nd Edition (UBS Publishers).
2. Niven, Zuckerman & Montgomer, Introduction to Theory of Numbers, 5th Edition (John Wiley & Sons).
3. Apostol, T. M., Introduction to Analytic Number Theory (Springer-Verlag).
4. Davenpart, H., Higher Arithmetic (Camb. Univ. Press).
5. Hardy & Wright, Number Theory (Oxford Univ. Press).
6. Dence, J.B, & Dence, T.P., Elements of the Theory of Numbers (Academic Press).

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SEMESTER III

MATH-617S: FIELD THEORY (COMPULSORY COURSE)
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.
4. All questions carry equal marks.

UNIT I

Fields, examples, characteristic of a field, subfield and prime field of a field, field extension, the degree of a field extension, algebraic extentions and transcendental extension, Adjunction of roots, splitting fields, finite fields, existence of algebraic closure, algebraically closed fields. Separable, normal and purely inseparable extensions. Perfect fields, primitive elements. Langrange's theorem on primitive elements.

UNIT II

Galois extensions, the fundamental theorem of Galois theory, Cyclotomic extensions, and Cyclic extensions, Applications of cyclotomic extensions and Galois theory to the constructability of regular polygons, Solvability of polynomials by radicals.

References:

1. Luther and Passi, Algebra Vol 4: Field Theory (Narosa Publishing).
2. S.Singh and Q Zameeruddin, Modern Algebra (Vikas Publisher, Delhi).
3. J-P. Escofier, Galois Theory, Springer-Verlag.
4. Gallian, Contemporary Abstract Algebra, Narosa Publishing House.
5. I. Stewart, Galois Theory, Chapman and Hall.

MATH-618S: TOPOLOGY (COMPULSORY COURSE)
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT – I

Topological Spaces, bases for a topology, the order topology, the product topology on $X \square Y$, the subspace
topology, closed sets and limit points, continuous functions, the product topology, the metric topology, the
quotient topology.
[Scope as in the relevant sections in Chapter 2 & 3 of the book 'Topology', second edition 2002, by James
R. Munkres.]
Connected spaces, connected subspaces of the real line, components and local connectedness.

UNIT-II

Compact spaces, compact space of the real line, limit point compactness, local compactness, nets.
[Scope as in the relevant sections in Chapter 3 of the book 'Topology', second edition 2002, by James R.
Munkres.]
The countability axioms, the separation axioms, Normal spaces, the Urysohn Lemma, the Urysohn Metrization
Theorem, the Tietze Extension Theorem, the Tychonoff Theorem.
[Scope as in the relevant sections in Chapters 4 and 5 of the book 'Topology', second edition 2002, by
James R. Munkres.]

References

1. James R. Munkers, Topology (Second Edition 2002), Prentice Hall of India.
2. James Dugundji, Topology, UBS Publishers.

3. John L. Kelley, General Topology (Van Nostrand)
4. Bourbaki , General Topology (Reading, Addison-Wesley).
5. G.G. Simmons, Introduction to Topology and Modern Analysis Tokyo, McGraw Hill, Kongakusha).
6. W.J. Thron, Topological Structures (N.Y.Holt) (Scope as in Chapters IV to XV, Chapter XVI: def.
16.4 and Results Including Tychonoff's theorem and Chapter XVIII of the reference 4).
7. E.T. Copson , Metric Spaces (Cambridge University Press).
8. S. Willord, General Topology (Addison Wesley Publishing Company).

MATH 661S: Probability and Mathematical Statistics-I
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT – I

Nature of Data and methods of compilation: Measurement scales, Attribute and variable, Discrete and
continuous variables. Collection, Compilation and Tabulation of data.

Representation of data: Histogram, Frequency Polygon, Frequency Curve, Ogives.
Measures of central tendency: Mean, Median, Mode, Geometric Mean, Harmonic Mean and their properties.
Measuring variability of data: Range, Quartile deviation, Deciles and Percentiles. Standard deviation,
Central and non-central moments, Sample and Population variance. Skewness and Kurtosis, Box and Whisker
plot.

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Correlation & Regression Analysis: Scatter diagram. Karl Pearson's and Spearman's rank correlation
coefficient. Linear Regression and its properties. Theory of attributes, independence and association.

UNIT – II
Probability: Intuitive concept of Probability, Combinatorial problems, conditional probability and
independence, Bayes' theorem and its applications.

Random Variables and Distributions: Discrete and Continuous random variables. Probability mass
function and Probability density function. Cumulative distribution function. Expectation of single and two
dimensional random variables. Properties of random variables. Moment generating function and probability
generating functions.
Distributions: Bernoulli distribution. Binomial distribution. Poisson distribution, Negative Binomial and
Hypergeometric distributions. Uniform, Normal distribution. Normal approximation to Binomial and Poisson
distributions. Beta, Gamma, Chi-square and Bivariate normal distributions. Sampling distribution of mean and
variance (normal population).
Chebyshev's inequality, weak law of large numbers, Central limit theorems.

References:
1 Goon, A.M., Gupta, M.K., Dasgupta, B: Fundamentals of Statistics, Vol-I & Vol-II (7th Ed. 1998).
2 Sheldon Ross : A First Course in Probability, 6th edition, Pearson Education Asia (2002).
3 Meyer, P.L: Introductory Probability and Statistical Applications.
4 Hogg, R.V. and Craig, T.: Introduction to Mathematical Statistics (MacMillan 2002).

MATH-672S: COMPUTATIONAL TECHNIQUES-I
Total Marks: 100
Computational Techniques –I (Theory)
Theory (4 hours per week)
Theory marks: 60 marks
Internal Assessment : 20 marks
Note: 1. Nine questions will be set in total - four from Unit I and five from Unit II.
2. The students will be required to attempt 5 questions, selecting at least two from each Unit.
3. Use of calculator is allowed for numerical work.
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UNIT-I
Programmer's model of a computer, Types of computers, General awareness of Computer Hardware –

CPU, Input, Output and peripherals, Software and Programming languages, General awareness of MS –
Word.
Programming in FORTRAN 77: Character set, constants, variables, Arithmetic expressions, Format
specification, READ, WRITE statements, unformatted I/O Statements, Unconditional GO TO, Computed
GO TO, Arithmatic and Logical IF statements, IF-THEN-ELSE, Nested IF-THEN-ELSE, ELSE-IF-THEN,
DO loops, Nested DO loops, CONTINUE Statement, Data statement, Double Precision, Logical Data,
Complex Data, WHILE Structure, Arrays-One and multidimensional, Subscripted Variables, Implied DO
loops, Sorting Problem, Function Subprograms and Subroutine subprograms, COMMON,
EQUIVALENCE, Simple programs.

UNIT-II
Solution of non-linear equations: Functional iteration, Bisection, Secant, Regula-Falsi, Newton-Raphson
and Bairstow's methods, Rate of convergence of these methods, Solution of linear system of equations:
Gauss elimination, Gauss Seidal and Triangularization methods, Condition of convergence of these methods.
Interpolation: Finite difference operators, Newton interpolation, Gauss Forward and backward interpolation
formulae, Newton's divided difference formula, Lagrange's Formula, Inverse interpolation,
Hermite interpolation.
Computational Techniques - I (Practical)
Practical (3 hours per week): 20 marks
Internal Assessment: No Marks

Writing programs in FORTRAN for the problems based on the methods studied in theory paper and to run
the program of PC.
Practical examination shall be conducted by the department/college concerned as per the following
distribution of marks:
Writing one Program of FORTRAN and running it on PC = 10 marks
Practical Record = 5 marks
Viva Voce = 5 marks

References:
1. C. F. Gerald and P. O. Wheatley: Applied Numerical Analysis, Pearson Education Asia.
2. M. K. Jain, S. R. K. Iyengar, R. K. Jain: Numerical Analysis for Scientific and Engineering
Computations, .New Age International (p) Ltd.
3. S. S. Shastry: Introduction to Numerical Analysis, Prentice Hall of India.
4. C. Xavier: FORTRAN 77 and Numerical Methods, New Age Int. Ltd.

MATH-673S: DIFFERENTIAL GEOMETRY-I
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.

4. All questions carry equal marks.

UNIT I

Tensors: Notations and Summation Convention, Transformation law for vectors, Cartesian tensors,
Algebra of Cartesian tensors, Differentiation of Cartesian tensors, The metric tensor, Transformation of
curvilinear co ordinates, General tensors, Contravariant, Covariant derivative of a vector, Physical
components, Christoffel symbol, Relation with the metric tensor, Covariant derivative of a tensor,
Riemann – Christoffel curvature tensor.

UNIT-II

Curves with Torsion: Tangent, Principal normal, Curvature, Binormal, Torsion, Serret-Frenet formulae,
Locus of Center of curvature, Circle of curvature, torsion of a curve, Involutes, Evolutes and Bertrand
curves.

Envelopes and Developable Surfaces: Surfaces, Tangent plane, normal, Envelope, Edge of regression,
Developable surfaces, Curvilinear co ordinates on a surface: Fundamental Magnitudes.

References:

1. Shanti Narayan: Cartesian Tensors, S. Chand and Company, New Delhi.
2. E. C. Young: Vectors and Tensor Analysis, Marcel Deccer (1994).
3. A. W. Joshi: Tensors and Riemanian Geometry.
4. C. E. Weatherburn: Differential Geometry.
5. A. Goetz: Introduction to Differential Geometry: Addison Wesley Publishing Company (1970).

MATH-674S: ELASTICITY –I
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT I

Tensors: Summation convention, Coordinate transformation, Cartesian tensors of different orders, Sum,
product and quotient laws, Contraction, Symmetric and skew symmetric tensors, Relation between alternate
and Kronecker tensors, Eigen values and Eigen vectors of a tensor of order two, Three scalar invariants of a
tensor of order two, Eigen vectors and values of symmetric tensors, Orthogonality of Eigen vectors and reality
of Eigen values, Gradient, Divergence and Curl in tensor notations, Gauss divergence theorem.

Analysis of Strain: Affine transformation, infinitesimal affine transformation, Geometrical interpretation of
component of Strain, Strain quadric of Cauchy.

UNIT-II

Analysis of Strain: Principal strains and Invariants, general infinitesimal deformation, Example of Strain,

Equations of Compatibility, Finite deformations.
Analysis of Stress: Stress tensor, Equation of equilibrium, Stress quadric of Cauchy, Principal stress and
invariants, Maximum normal and shear stress, Plane stress, generalized plane stress, Airy stress function,
General solution of biharmonic equation, stresses and displacements in terms of complex potentials, simple
problems.

References:
1. Shanti Narayan: Cartesian Tensor, Sultan Chand and Company, N. Delhi.
2. I. S. Sokolnikoff: Mathematical Theory of Elasticity, Mc-Graw Hill, Inc.
3. A. E. H. Love: A Treatise on Mathematical Theory of Elasticity, Dover Publications.
4. K. E. Bullen and B. A. Bolt: An Introduction to the Theory of Seismology, Cambridge University
Press, Cambridge (1985).

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MATH-675S: SPECIAL FUNCTIONS
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT I
Hypergeometric Functions: The hypergeometric series, An integral formula for the hypergeometric series,
The hypergeometric equation, Linear relations between the solutions of the hypergeometric equation, Relations
of contiguity, The confluent hypergeometric function, Generalised hypergeometric series.
Legendre Functions: Legendre polynomials, Recurrence relations for the Legendre polynomials, The
formulae of Murphy and Roderigues, Series of Legendre polynomials, Legendre's differential equation,
Neumann's formula for the Legendre functions, Recurrence relations for the functions $Q_n(\mu)$, The use of
Legendre functions in potential theory, Legendre's associated functions, Integral expression for the associated
Legendre function, Surface spherical harmonics, Use of associated Legendre functions in wave mechanics.

UNIT II
Bessel Functions: The origin of Bessel functions, Recurrence relations for the Bessel coefficients, Series
expansions for the Bessel coefficients, Integral expressions for the Bessel coefficients, The addition formula
for the Bessel coefficients, Bessel's differential equation, Spherical Bessel functions, Integrals involving
Bessel functions, The modified Bessel functions, The Ber and Bei functions, Expansions in series of Bessel
functions, The use of Bessel functions in potential theory, Asymptotic expansion of Bessel functions.
The Functions of Hermite And Laguerre: The Hermite polynomials, Hermite's differential equation,

Hermite functions, the occurrence of Hermite functions in wave mechanics, The Laguerre polynomials,
Laguerre's differential equation, The associated Laguerre polynomials and functions, The wave functions for
the hydrogen atom.
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References:
1. I. N. Sneddon: Special Functions of Mathematical Physics and Chemistry, Edinburg, Oliver & Boyd,
1956.
2. G. Andrews, R. Askey & R. Roy, Special Functions, Cambridge, 1999.
3. L. Andrews, Special Functions for Engineers and Applied Scientists, Macmillan, 1985.
4. N. N. Lebedev, Special Functions & Their Applications, Revised Edition, Dover, 1976.
5. W. W. Bell, Special Functions for Scientists and Engineers, Dover, 1968.

MATH-676S: FLUID MECHANICS –I
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I
Real fluids and ideal fluids, velocity of fluid at a point, streamlines, pathlines, streaklines, velocity potential,
vorticity vector, local and particle rate of change, equation of continuity, irrotational and rotational motion,
acceleration of fluid, conditions at rigid boundary.
Euler's equation of motion, Bernoulli's equation, their applications, Potential theorems, axially symmetric
flows, impulsive motion, Kelvin's Theorem of circulation, equation of vorticity.

UNIT-II
Some three dimensional flows: Sources, sinks and doublets, images in rigid planes, images in solid sphere,
Stoke's stream function.
Two dimensional flows: Complex velocity potential, Milne Thomson Circle Theorem and applications,
Theorem of Blasius, vortex rows, Karman vortex street.

References
1. Chorlton, F. (Text Book of Fluid Dynamics).
2. L.D.Landau & E. N. Lipschitz (Fluid Mechanics).
3. G. K. Batchelor (An Introduction to Fluid Mechanics).
4. Kundu and Cohen (Fluid Mechanics).
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MATH-678S: LINEAR PROGRAMMING
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

Linear Programming and examples, Convex Sets, Hyperplane, Open and Closed half-spaces, Feasible,
Basic Feasible and Optimal Solutions, Extreme Point & graphical methods. Simplex method, Charnes-M
method, Two phase method, Determination of Optimal solutions, unrestricted variables, Duality theory,
Dual linear Programming Problems, fundamental properties of dual Problems, Complementary slackness,
Unbounded solution in Primal. Dual Simplex Algorithm, Sensitivity analysis.

UNIT-II

Parametric Programming, Revised Simplex method, Transportation Problems, Balanced and unbalanced
Transportation problems, U-V method, Paradox in Transportation problem, Assignment problems, Integer
Programming problems: Pure and Mixed Integer Programming problems, 0-1 programming problem,
Gomary's algorithm, Branch & Bound Technique. Travelling salesman problem [scope as in reference no. 2].
[Scope as in Chapter 2-5; Chapter 7-9 of the reference no.1,chapter 4-6 of reference no. 3, chapter 5 of
reference no. 2].

References:

1. G. Hadley, Linear Programming, Narosa Publishing House, 6th edition. 1995.
2. N.S. Kambo, Mathematical Programming Techniques, Affiliated East-West Press Pvt.Ltd. New
Delhi, Madras.
3. Suresh Chandra, Jayadeva, Aparna Mehra, Numerical Optimization with Applications, Narosa
Publishing House,1st edition,2009.
4. S.M. Sinha, Mathematical Programming, Theory and Methods, Elsevier, 1st edition, 2006.

MATH 680S: Geometry of Numbers-I
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

Convex sets in Euclidean space IR_n, Lattices, basics of Lattices, Minkowskis' Fundamental Theorem
and its applications and generalizations. Hermites' Theorem on minima of +ve definite quadratic forms.

UNIT-II

Minkowskis' 2nd Theorem, Mahlers' Compactness theorem, critical determinants, critical lattices.

References:

1. C. D. Olds, A. Lax and G. P. Davidoff. The Geometry of Numbers.
2. J.W.S.Cassels - An Introduction to Geometry of Numbers.
3. C.C.Lekkerkerker and P.Gruber - Geometry of Numbers.
4. C.A.Rogers - Packings and Coverings.

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SEMESTER IV

MATH-637S: LINEAR ALGEBRA (COMPULSORY COURSE)
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.
4. All questions carry equal marks.

UNIT I

Definition and examples of vector spaces (over arbitrary fields), subspaces, direct sum of subspaces, linear dependence and independence, basis and dimensions, linear transformations, quotient spaces, algebra of linear transformations, linear functions, dual spaces, matrix representation of a linear transformation, rank and nullity of a linear transformation, invariant subspaces.

UNIT II

Characteristic polynomial and minimal polynomial of a linear transformation, eigenvalues and eigenvectors of a linear transformation, diagonalization and triangularization of a matrix, Jordan and Rational canonical forms, bilinear forms, symmetric bilinear forms, Sylvester's theorem, quadratic forms, Hermitian forms, Inner product spaces, Gram-schmidt orthonormalization process.

References:

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, First Course in Linear Algebra (Wiley Eastern Delhi).
2. J. Gilbert and L. Gilbert: Linear Algebra and Matrix Theory (Academic Press).
3. S.Singh and Q Zameeruddin, Modern Algebra (Delhi, Vikas).
4. I.N. Herstein, Topics in Algebra (Delhi Vikas).
5. V.Bist and V. Sahai, Linear Algebra (Narosa, Delhi).

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MATH 638S: Functional Analysis (Compulsory Course)
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

Banach Spaces with examples of $L_P([a,b])$ and $C([a,b])$, Hahn Banach theorem, open mapping theorem,
closed graph theorem, Baire Category theorem, Banach Steinhauns theorem (uniform boundedness
principle), Boundedness and continuity of linear transformation, Dual Spaces, embedding in second dual.
[Scope as in 3.7, §5-§7, 9.1, 9.2, 10.3-10.7, 11.1-11.3, 13.1-13.5 of the book 'Functional Analysis' by
B.V. Limaye, 1985, Wiley Eastern Ltd.]

UNIT-II

Hilbert space, orthonormal basis, Bessel's inequality, Riesz Fischer theorem, Parseval's identity, bounded
Linear functionals; projections, Riesz Representation theorem, adjoint operators, self adjoint, normal, unitary
and isometric operators.
[Scope as in §21, §22, 23.2, 23.7-23.9, §24 upto 24.5, §25, 26.1-26.3 of the book 'Functional Analysis' by
B.V. Limaye, 1985, Wiley Eastern Ltd**.]**

References:

1. S.K. Berberian - Introduction to Hilbert Spaces, (N.Y. O.W.P.).
2. C. Goffman and G. Pedrick - First course in Functional Analysis, N. Delhi Prentice Hall of India).
3. F.K. Riesz and Bela Sz Nagy - Functional Analysis, (N.Y., Wingar).
4. A.H. Siddiqui - Functional Analysis (Tata-McGraw Hill).
5. Walter Rudin – Real and Complex Analysis (McGraw-Hill) 3rd Edition.
6. B.V. Limaye – Functional Analysis (Wiley Eastern Ltd.), 1985.
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MATH 681S: Probability and Mathematical Statistics-II
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I

Point and Interval Estimation: General concept of Point estimation, unbiasedness, consistency,
efficiency and Sufficiency. Factorization theorem, completeness, Rao-Blackwell theorem, Cramer-Rao
inequality. Maximum likelihood method of estimation and method of moments. Interval estimation,
confidence intervals for means, difference of means and variances.

UNIT–II

Hypothesis Testing: The basic idea of significance test. Null and alternative hypothesis, Type-I and Type-
II errors. Uniformly most powerful tests, Likelihood Ratio tests. t, Chi-square and F-distributions. Tests of
significance based on t, Chi-square and F. One way and two way Analysis of Variance (ANOVA).
Non-Parametric Tests: Sign test, Wilcoxon signed rank test, Mann-whitney test.

References:
1 Goon, A.M., Gupta, M.K., Dasgupta, B: Fundamentals of Statistics, Vol-I (7th Ed. 1998).
2 Dudewicz, E.J and Mishra, S.N: Modern Mathematical Statistics (1988).
3 Goon, A.M., Gupta, M.K., Dasgupta, B: Fundamentals of Statistics, Vol-II (7th Ed. 1998).
4 Deniel, W.W: Aplied Nonparametric Statistics (1999).
5 Rohtagi, V.K and Saleh A.K.M.E.: An Introduction to Probability Theory Mathematical Statistics
(2000).
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MATH-692S: COMPUTATIONAL TECHNIQUES-II
Total Marks: 100
Computational Techniques –II (Theory)
Theory (4 hours per week)
Theory marks: 60 marks
Internal Assessment : 20 marks
Note: 1. Nine questions will be set in total - four from Unit I and five from Unit II.
2. The students will be required to attempt 5 questions, selecting at least two from each Unit.
3. Use of calculator is allowed for numerical work.
UNIT-I
MS Excel: Introduction, Functions and Formulae, Graphics and Data base.
Programming in C: Historical development of C, Character set, Constants, Variables, Keywords,
Operators, Hierarchy of arithmetic operations, if and if-else statements, Logical and Conditional Operators,
Switch structure, while structure, do-while and for-Loops, Nested loops, Break and Continue statements,
Arrays, Functions, Print Function, Function Declaration and Function Prototype, Return Statement, Local
and Global Variables, Passing Arrays as parameter, Recursion and Library Functions, Files in C, Introduction
to pointers, Simple programs.

UNIT-II
Numerical Differentiation, Numerical Integration: General formulae, Trapeziodal rule, Simpson's 1/3 and 3/8
rule, Romberg integration, Newton-Cotes formulae, Gaussian integration.
Solution of Ordinary Differential Equations: Taylor's series, Picard method of Successive approximations,
Euler's method, Modified Euler's method, Runge Kutta Method-2nd and 4th order, Predictor-Corrector
methods, Milne-Simpson's method, Adam's – Bashforth method, Finite difference method for boundary value
problems.
Approximation of functions: Chebyshev Polynomials, Orthogonality of Chebyshev polynomials, Lanczos
Economization of Power series.

Computational Techniques –II (Practical)
Practical (3 hours per week): 20 marks
Internal Assessment : No marks

Writing programs in C for the problems based on the methods studied in theory paper and to run the
program of PC.

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Practical examination shall be conducted by the department/college concerned as per the following distribution
of marks:
Writing one Program of C and running it on PC = 10 marks
Practical Record = 5 marks
Viva Voce = 5 marks

References:
1. C. F. Gerald and P. O. Wheatley: Applied Numerical Analysis, Pearson Education Asia.
2. M. K. Jain, S. R. K. Iyengar, R. K. Jain: Numerical Analysis for Scientific and Engineering
Computations. New Age International (p) Ltd.
3. S. S. Shastry: Introduction to Numerical Analysis, Prentice Hall of India.
4. C. Xavier: C Language and Numerical Methods, New Age Int. Ltd.
5. Y. Kanetkar: Let Us C, B P B Publication.

MATH-693S: DIFFERENTIAL GEOMETRY-II
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT I
Curves on a Surface: Principal directions and curvature, First and second curvature, Euler's theorem,
Dupin theorem, Dupin's indicatrix, Normal curvature, Mean curvature, Umblic points, Conjugate
directions, conjugate system, asymptotic lines, Curvature and Torsion, Isometric lines, Null lines.

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UNIT II
Equations of Gauss and of Codazzi:
Gauss's formulae for r_{11}, r_{12}, r_{22}, Gauss Characteristic equation,
Mainardi-Codazzi relation, Bonnet's theorem.
Quadric Surfaces: Geodesics, Geodesic property, equation of geodesics, surface of revolution, Torsion of
geodesic, Central quadrics, Fundamental magnitudes, The fundamental theorem of surface theory,
Liouville's equation, Joachimsthal's theorem.

References:
1. C. E. Weatherburn: Differential Geometry.
2. A. Goetz: Introduction to Differential Geometry: Addision Wesley Publishing Company, (1970).

MATH-694S: ELASTICITY –II
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT I

Equations of Elasticity: Generalized Hook's Law, Homogeneous isotropic media, Equilibrium and
dynamical equations for isotropic media, Strain energy function, Uniqueness of solution, Beltrami-Michell
Compatibility equations, Saint Venant's Principal.
D'Alembert's method of one dimensional wave equation, Waves in three dimensions, Harmonic waves,
Spherical waves, Superposition of waves and stationary waves, Solution of equation of wave motion of
stationary type by method of separation of variables, Cartesian, plane polar and spherical polar
coordinates.

UNIT-II

Elastic Waves: Wave propagation in isotropic elastic solid medium, Waves of dilation and distortion,
Rayleigh waves, Love waves, Reflection of P, SV and SH-waves from free surface of a half-space,
Reflection and refraction of elastic waves (P, SV and SH-waves) at Solid-Solid and Solid-Liquid interface.

References:

1. P. K. Ghosh, The Mathematics of Waves and Vibrations, Macmillan Company of India Limited.
2. I. S. Sokolnikoff: Mathematical Theory of Elasticity, Mc-Graw Hill, Inc.
3. A. E. H. Love: A Treatise on Mathematical Theory of Elasticity, Dover Publications.
4. K. E. Bullen and B. A. Bolt: An Introduction to the Theory of Seismology, Cambridge University
Press, Cambridge (1985).
5. P. M. Shearer: Introduction to Seismology, Cambridge University Press (1999).

MATH 695S: INTEGRAL TRANSFORMS AND THEIR APPLICATIONS

Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT I

Laplace Transforms : Definition and examples, Existence theorem and basic properties, Convolution
theorem and properties of convolution, Differentiation and Integration of Laplace transform, the inverse
Laplace transform and examples, Tauberian theorems for Laplace transforms and Watson's Lemma,

Laplace transforms of fractional integrals and fractional derivatives.

Applications of Laplace Transform to Solve/Evaluate : Ordinary and partial differential equations, Initial and boundary value problems, Integral equations, Definite integrals, Difference equations and Differential-difference equations.

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Finite Laplace Transforms : Definition and examples, Basic operational properties, Applications, Tauberian theorems for finite Laplace transforms.

Hankel Transforms : Definition and examples, operational properties, Applications to solve partial differential equations.

UNIT II

Fourier Transforms : Fourier Integral formulas, Definition and examples, Basic properties, Fourier cosine and sine transforms and examples, Basic properties of Fourier cosine and sine transforms, Multiple Fourier transforms.

Applications of Fourier Transform to Solve/Evaluate : Ordinary and Partial differential equations, Integral equations, Definite integrals. Applications of Multiple Fourier transform.

Finite Fourier Cosine and Sine Transforms : Definition and examples, Basic properties, Applications, Multiple finite Fourier transforms and their applications.

Mellin Transforms : Definition and examples, Basic operational properties and Applications.

References :

1. Loknath Debnath, Integral Transforms and Their Applications, CRC Press, Inc., 1995.
2. Brian Davies, Integral Transforms and their Applications, 3rd Edition, Springer-Verlag, New York, Inc, 2001.
3. Ronald N. Bracewell, Fourier Transform and Its Applications, 2nd Edition, McGraw-Hill Inc., US, 1986.
4. Joel L. Schiff, The Laplace Transform: Theory and Applications, Springer-Verlag, New York, Inc, 1999.
5. P.P.G. Dyke, An Introduction to Laplace Transforms and Fourier Series, Springer-Verlag, London, 2001.
6. Austin Keane, Integral Transforms, Science Press, 1965.

MATH 696S : Fluid Mechanics-II

Total Marks : 100

Theory : 80 Marks

Internal Assessment : 20 Marks

Time : 3 hrs.

Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.

2. Question No.1 is compulsory and will consist of short answer type questions covering the whole syllabus.

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3. There will be four questions from each Unit and the candidates will be required to attempt two questions from each Unit.

4. All questions carry equal marks.

UNIT-I

Viscous Flows: Stress components, Stress and strain tensor, coefficient of viscosity and Laminar flow,

plane Poiseuille flows and Couette flow. Flow through tubes of uniform cross section in the form of circle,
Ellipse, equilateral triangle, annulus, under constant pressure gradient.
Diffusion of vorticity. Energy dissipation due to viscosity, steady flow past a fixed sphere, dimensional
analysis, Reynold numbers, Prandtl's boundary layer, Boundary layer equation in two dimensions, Karman
integral equation.

UNIT-II
Elements of wave motion, waves in fluids, surface gravity waves, standing waves, dispersion relation, path
of particles, waves at the interface of two liquids, equipartition of energy, group velocity, energy of
propagation of waves.

References
1. Chorlton, F. (Text Book of Fluid Dynamics).
2. L.D.Landau & E. N. Lipschitz (Fluid Mechanics).
3. G. K. Batchelor (An Introduction to Fluid Mechanics).
4. Kundu and Cohen (Fluid Mechanics).

MATH 698S : Non-Linear Programming
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.
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UNIT-I
Nonlinear Programming: Convex functions, Concave functions, Definitions and basic properties, subgradients
of convex functions, Differentiable convex functions, Minima and Maxima of convex function and concave
functions. Generalizations of convex functions and their basic properties. Unconstrained problems, Necessary and sufficient optimality criteria of first and second order. First order
necessary and sufficient Fritz John conditions and Kuhn-Tucker conditions for Constrained programming
problems with inequality constraints, with inequality and equality constraints. Kuhn Tucker conditions and
linear programming problems.

UNIT-II
Duality in Nonlinear Programming, Weak Duality Theorem, Wolfe's Duality Theorem, Hanson-Huard
strict converse duality theorem, Dorn's duality theorem, strict converse duality theorem, Dorn's Converse
duality theorem, Unbounded dual theorem, theorem on no primal minimum. Duality in Quadratic
Programming.
Quadratic Programming:Wolfe's method, Beale's method for Quadratic programming. Linear fractional programming, method due to Charnes and Cooper. Nonlinear fractional programming,
Dinkelbach's approach.

Game theory - Two-person, Zero-sum Games with mixed strategies, graphical solution, solution by Linear
Programming.
[Scope as in Chapter 17 of reference no. 4, Chapter 3 & 4 of reference no.1, chapter 24, 26 and 28 of
reference no. 2, Chapter 8 of reference no. 3, Chapter 16 of reference no. 5]

References :

1. Mokhtar S. Bazaraa & C.M. Shetty, Nonlinear Programming, Theory of Algorithms, 2nd edition,
Wiley, New-York, 2004.
2. S. M. Sinha, Mathematical Programming, Theory and Methods, Elsevier, 1st edition, 2006.
3. O. L. Mangasarian, Nonlinear Programming, TATA McGraw Hill Company Ltd. (Bombay, New
Delhi), 1st edition, 1969.
4. Kanti Swarup, P.K. Gupta & Man Mohan, Operations Research, Sultan Chand & Sons, New Delhi
9th edition, 2001.
5. N. S. Kambo, Mathematical Programming Techiques, Affiliated East-West Press Pvt. Ltd., New
Delhi, Madras.

MATH 700S: Geometry of Numbers-II
Total Marks : 100
Theory : 80 Marks
Internal Assessment : 20 Marks
Time : 3 hrs.
Note: 1. The question paper will consist of 9 questions. Candidates will attempt total five questions.
2. Question No.1 is compulsory and will consist of short answer type questions covering the
whole syllabus.
3. There will be four questions from each Unit and the candidates will be required to attempt
two questions from each Unit.
4. All questions carry equal marks.

UNIT-I
Packing, Packing-density of Lattices, Covering Constants, Lattice and non-Lattice Covering for
n-dimensional convex bodies.

UNIT-II
Minima of indefinite binary quadratic forms. Homogeneous and non-homogeneous minima of indefinite
quadratic forms.

References:

1. C.D.Olds, A. Lax and G.P.Davidoff, The Geometry of Numbers.
2. J.W.S.Cassels – An Introduction to Geometry of Numbers.
3. C.C.Lekkerkerker and P.Gruber – Geometry of Numbers.
4. C.A.Rogers – Packings and Coverings.
5. J.H.Conway and N.J.A.Sloane – Sphere Packings, Lattices and Groups.

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Published by : Prof. A. K. Bhandari, Registrar, Panjab University, Chandigarh.

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Ved Ratan