

SYLLABUS

For

**M.A./ M.Sc. in Mathematics
(Semester System)**

(Effective from the Academic Session 2007-2008 and onwards)



**THE UNISERSITY OF BURDWAN
DIRECTORATE OF DISTANCE EDUCATION
Golapbag, Burdwan-713 104
West Bengal**

THE UNIVERSITY OF BURDWAN

Syllabus For M.A./M.Sc. in Mathematics

Duration of P.G course of studies in Mathematics shall be two years with Semester-I, Semester-II, Semester-III and Semester-IV each of six months duration leading to Semester-I, Semester-II, Semester-III and Semester-IV examination in Mathematics at the end of Each Semester. Syllabus for P.G courses in Mathematics at the end of each Semester. Syllabus for P.G courses in Mathematics is hereby framed according to the following schemes and structures.

Scheme: Total Marks= 1000 with 250 Marks in each Semester comprising of five papers in each Semester with 50 marks in each paper. In each theoretical paper 10% Marks is allotted for Internal Assessment. There are four theoretical papers and one practical paper in Semester-III. All students admitted to P.G course in mathematics shall take courses of Semester-I and Semester-II; and from the Semester-II they will opt for either Pure Stream or Applied Stream in Mathematics. The option norm is to be framed by the Department in each year. In each stream of Semester-III, the first three papers are general and the last two papers are special papers. In each stream of Semester-IV, the first two papers are general and the next two papers are special papers and the fifth paper is the term paper. In the Semester-III and Semester-IV, the Department will offer a cluster of special papers and the students will have to choose one according to the norms to be decided by the Department. The term paper is related with the respective special papers and the mark distribution is 30 for written submission, 15 for Seminar Presentation and 5 for Viva-Voice. It should be noted that some special papers will be included in future as per discretion of the Department.

1. For semester III & IV of DDE, the students will be divided eqally between pure and applied streams and the same policy will be followed in respect of special papers to the corresponding branches. The norm for the allotment of students to the streams and special papers will be as follows.
 - (i) The marks in Mathematics only in Hons or Pass will be considered.
 - (ii) Hons students will be given preference over the pass students.

COURSE STRUCTURE

SEMESTER STRUCTURE OF M.A/M.SC. SYLLABUS IN MATHEMATICS (SEMESTER-I, II, III, IV)

Semester-I

Duration 6 Months

Total Marks: 250 Total No. of Lectures : 50 Hours per paper

Each Theoretical Paper Containing
45 Marks and 5 Marks for Internal Assessment

| Paper | | Marks |
|---------|---|-------|
| MCG101: | Functional Analysis-I (27+3) | 30 |
| | Real Analysis-I (18+2) | 20 |
| MCG102: | Linear Algebra (27+3) | 30 |
| | Modern Algebra (18+2) | 20 |
| MCG103 | Elements of General Topology (27+3) | 30 |
| | Complex Analysis-I (18+2) | 20 |
| MCG104 | Ordinary Differential Equations & Special Functions (27+3) | 30 |
| | Operations Research- I (18+2) | 20 |
| MCG105 | Principle of Mechanics-I (27+3) | 30 |
| | Numerical Analysis (18+2) | 20 |

Semester-II

Duration : 6 Months

Total Marks: 250 Total No. of Lecturers : 50 Hours per paper

Each Theoretical Paper Containing
45 Marks and 5 Marks for Internal Assessment

| Paper | | Marks |
|---------|---------------------------------------|-------|
| MCG201: | Complex Analysis-II(27+3) | 30 |
| | Real Analysis -II (18+2) | 20 |
| MCG202: | Partial Differential Equations (27+3) | 30 |
| | Differential Geometry (18+2) | 20 |
| MCG203: | Operations Research- II (27+3) | 30 |
| | Principle of Mechanics-II (18+2) | 20 |
| MCG204: | Computer Programming (27+3) | 30 |
| | Continuum Mechanics- I (18+2) | 20 |
| MCG205: | Computer Aided Numerical Practical | 50 |

Semester III & IV Separated for Pure and Applied Stream

Semester-III: Pure Stream

Duration : 6 Months

Total Marks : 250 Total No. of Lecturers : 50 Hours per paper

Each Theretical Paper Containing
45 Marks and 5 Marks for Internal Assessment

| Paper | | Marks |
|---------|--|-------|
| MPG301: | Modern Algebra -III (27+3) | 30 |
| | General Topology-I(18+2) | 20 |
| MPG302: | Graph Theory (36+4) | 40 |
| | Mathematical Logic-I(9+1) | 10 |
| MPG303: | Set Theory & Mathematical Logic-II(27+3) | 30 |
| | Functional Analysis- II (18+2) | 20 |
| MPS304: | Special Paper-I (45+5) | 50 |
| MPS305: | Special Paper-II (45+5) | 50 |

Semester-IV : Pure Stream

Duration : 6 Months

Total Marks : 250 Total No. of Lectures : 50 Hours per paper

Each Theoretical Paper Containing
45 Marks and 5 Marks for Internal Assessment

| Paper | | Marks |
|---------|--------------------------------|-------|
| MPG401: | Modern Algebra-III (45+5) | 50 |
| MPG402: | General Topology-II (27+3) | 30 |
| | Functional Analysis-III (18+2) | 20 |
| MPS403: | Special Paper- III (45+5) | 50 |
| MPS404: | Special Paper- IV (45+5) | 50 |
| MPT405 | Term Paper (30+15+5) | 50 |

Term Paper MPT405 is related with the Special papers and the Marks distribution is 30 Marks for written submission and 15 Marks for Seminar Presentaion and 5 Marks for Viva-voice.

Semester-III : Applied Stream

Duration : 6 Months

Total Marks: 250 Total No. of Lecturers: 50 Hours per paper

Each Theoretical Paper Containing
45 Marks and 5 marks for Internal Assesmsnt

| Paper | | Marks |
|---------|---|-------|
| MAG301: | Methods of Applied Mathematics-I(45+5) | 50 |
| MAG302: | Methods of Applied Mathematics-II(27+3) | 30 |
| | Theory of Electro Magnetic Fields(18+2) | 20 |
| MAG303: | Continuum Mechanics-II (27+3) | 30 |
| | Dynamical System (18+2) | 20 |
| MAS304: | Special Paper -I (45+5) | 50 |
| MAS305: | Special Paper- II (45+5) | 50 |

Semester-IV : Applied Stream

Duration : 6 Months

Total Marks: 250 Total No. of Lecturers : 50 Hours per paper

Each Theotetical Paper Contaioning
45 Marks and 5 Marks for Internal Assesment

| Paper | | Marks |
|---------|--------------------------------------|-------|
| MPG401: | Continuum Mechanics-III (45+5) | 50 |
| MAG402: | Elements of Quantum Mechanics (27+3) | 30 |
| | Chaos and Fractals (18+2) | 20 |
| MAS403: | Special Paper- III (45+5) | 50 |
| MAS404: | Special Paper-IV (45+5) | 50 |
| MAT405: | Term Paper (30+15+5) | 50 |

Term Paper MAT405 is related with the Special papers and the Marks distribution is 30 Marks for written submission and 15 Marks for Seminar Presentation and 5 Marks for Viva-voice.

Cluster of Special Paper-I & III For Semester-III & IV respectively each of 50 marks (Pure Stream) :

- A Differential Geometry of Manifolds- I & II
- B Advanced Real Analysis- I & II
- C Advanced Functional Analysis- I & II
- D Rings of Continuous Function- I & II
- E Theory of Rings and Algebra- I & II
- F Non-linear Optimization in Banach Spaces - I & II
- G Harmonic Analysis- I & II
- H Applied Functional Analysis- I & II

Cluster of Special Paper-II & IV For Semester-III & IV respectively each of 50 marks (pure Stream):

- A Measure and Integration - 1 & II
- B Operator Theory and Applications- 1 & II
- C Algebraic Topology- 1 & II
- D Lattice Theory- 1& II
- E Advanced Operations Research-1 & II
- F Geometric Functional Analysis - 1 & II
- G Proximities, Nearness and Extensions of Topographical Spaces-1 & II
- H Advanced Complex Analysis- 1 & II

Cluster of Special Paper- I & III For Semestar-III & IV respectively each of 50 marks (Applied Stream):

- A Viscous Flows, Boundary Layer Theory and Magneto Hydrodynamics- I & II
- B Elasticity- I & II
- C Elasticity and Theoretical Seismology- I & II
- D Applied Functional Analysis- I & II

Cluster of Special Paper- II & IV For Semestar-II & IV respectively each of 50 marks (Applied Stream):

- A Quantum Mechanics- 1 & II
- B Advanced Operations Research- 1 & II
- C Inuiscid Compressible Flows and Turbulence - 1& II
- D Computational Fluid Dynamics- 1 & II

* All the students will have to take the Special paper- I & III for Semester- III & IV and Special Paper- II & IV for Semester -III & IV respectively from the same topic, and the Special paper- I & II and Special paper- III & IV from the respective clusters of special papers for Semester-III and Semester-IV respctively. The clusters of special papers to be offered in a particular year shall be decided by the Department. Students of Applied Mathematics stream may also opt *Applied Functional Analysis- I & II* As the Special paper - I and Special paper-III respectively, if they so desire. Students of Pure Mathematics Stream may also opt the *Advanced Operations Research- I & II* as the Special paper-II and Special paper-IV respectively, if they so desire.

DETAILED SYLLABUS
SEMESTER-I
Paper- MCG101
(Functional Analysis-I & Real Analysis-I)

Group-A
Functional Analysis-I (Marks- 30)

Baire category theorem. Normed linear spaces, continuity of norm function, Banach spaces, Spaces C^n , $C[a,b]$ (with supmetric), C_0 , l_p ($1 \leq p \leq \infty$) etc;

Linear operator, boundedness and continuity, examples of bounded and unbounded linear operators.

Banach contraction Principle- application to Picard's existence theorem and Implicit function theorem.

Inner product, Hilbert spaces, examples such as l_2 spaces, $l_2[a,b]$ etc; C-S inequality, Parallelogram law, Pythagorean law, Minkowski inequality, continuity and derivatives of functions from \mathbf{R}^m to \mathbf{R}^n .

Group-B
Real Analysis- I (Marks-20)

Monotone functions and their discontinuities, Functions of bounded variation on an interval, their properties, Riemann Stieltjes integral, existence, convergence problem and other properties.

Lebesgue outer measure, countable subadditivity, measurable sets and their properties, Lebesgue measure, measurable functions, equivalent functions, continuity and measurability, monotonicity and measurability, operation on collection of measurable functions, pointwise limit of sequence of measurable functions, measurability of Supremum and Infimum, simple function and measurable function.

References

1. I.P Natanson- *Theory of Functions of a Real Variable, Vol. I, Fedrick Unger Publi. Co., 1961*
2. Lusternik and Sovolev - *Functional Analysis*
3. A.H Siddiqui- *Functional Analysis with application*, TMG Publishing Co. Ltd, New Delhi
4. K.K. Jha- *Functional Analysis, 1986*
5. Vulikh- *Functional Analysis*
6. G. Bachman & L. Narici- *Functional Analysis*, Academic Press, 1966
7. A.E Taylor- *Functional Analysis, John Wiley and Sons, New York, 1958*
8. E. Kreyszing- *Introductory Functional Analysis with Applications*, Wiley Eastern, 1989
9. L.V. Kantorovich and G.P. Alilov- *Functional Analysis*, Pergamon Press, 1982

10. B.K. Lahiri- *Elements of Functional Analysis*, The World Press Pvt. Ltd., Kolkata, 1994
11. G.F. Simmons- *Introduction to Topology and Modern Analysis*, Mc.Graw Hill, New York, 1963
12. B.V. Limaye- *Functional Analysis*, Wiley Eastern Ltd
13. Burkil & Burkil- *A Second Course of Mathematical Analysis*, CUP, 1980.
14. Goldberg- *Real Analysis*, Springer-Verlag, 1964
15. Royden- *Real Analysis*, PHI, 1989
16. Lahiri. & Roy - *Real Analysis*, World Press, 1991.e
17. Apostol- *Mathematical Analysis*, Narosa Publi. House, 1885
18. Titchmarsh- *Theory of Functions*, CUP, 1980
19. W. Rudin- *Principle of Mathematical Analysis*, Mc Graw Hill, Student Edn.
20. Charles Swartz: *Measure, Integration and Function Spaces*, World Scientific, 1994.

Paper- MCG102
(Linear Algebra & Modern Algebra-I)
Group- A
Linear Algebra (Marks- 30)

Vector spaces, Euclidean space, Unitary space, orthonormal basis, Gram-Schmidt orthogonalization process.

Linear transformation in finite dimensional spaces, matrix of linear, rank and nullity, annihilator of subset of a vector space.

Eigen vectors, spaces spanned by eigen vectors, similar and congruent matrices, characteristic polynomial, minimal polynomial, diagonalization, diagonalization of symmetric and Hermitian matrices, Cayley-Hamilton theorem, reduction of a matrix to normal form, Jordan Canonical form.

Quadratic form, reduction to normal form, Sylvester's law of inertia, simultaneous reduction of two quadratic forms, application to Geometry & Mechanics.

Group-B

Modern Algebra- I (Marks-20)

Groups: Homomorphism, Isomorphism of groups, First and Second isomorphism theorems, automorphisms, groups of order 4 and 6, Normal sub groups and correspondence theorem for groups, simple groups.

Rings: Ring, commutative rings with identity, Prime & irreducible elements division ring, Quaternions, idempotent element, Boolean ring, ideals, Prime ideal, maximal ideal, Isomorphism theorems, relation between Prime and maximal ideal, Euclidean domain, Principal ideal domain, Unique factorization domain, Polynomial rings.

References:

1. I.N, Herstein- *Topics in Algebra (Vikas)*.
2. P.B. Bhattacharya, S.K. Jain & S.R. Noyapal- *Basic Abstract Algebra (Cambridge)*
3. T.W. Hungerford- *Algebra (Springer)*.
4. Malik, Mordeson & Sen- *Fundamentals of Abstract Algebra (Tata MaGraw-Hill)*
5. Sen, Ghosh & Mukhopadhyay- *Topics in Abstract Algebra (University Press)*.
6. P. M. Cohn- *Basic Algebra*.
7. S. lang- *Linear Algebra*.
8. S. Lang- *Linear Algebra*.
9. Hoffman & Kunze- *Linear Algebra (Prentice Hall)*.
10. S. Kumareson- *Linear Algebra*
11. Rao & Bhimsankaran- *Linear Algebra*.

Paper- MCG103 **(Elements of General Topology & Complex Analysis-I)** **Group - A** **Elements of General Topology (Marks-30)**

Topological spaces; definition, open sets, closed sets, closure, denseness, neighbourhood, interior points, limit points, derived sets, basis, subbasis, subspace.

Alternative way of defining a topology using Kuratowski closure operators and neighbourhood systems.

Continuous functions, homeomorphism and topological invariants.

First and second countable spaces, Lendel of spaces, separable spaces and their relationship.

Separation axioms: $T_0, T_1, T_2, T_{3/2}, T_4$ spaces, their simple properties and their relationship.

Introduction to connectedness and compactness.

Group-B

Complex Analysis-I (Marks-20)

Complex integration, line integral and its fundamental properties, Cauchy's fundamental theorem, Cauchy's integral formula and higher derivatives, power series expansion of analytic functions.

Zeros of analytic functions and their limit points, entire functions, Liouville's theorem.

Fundamental theorem of algebra.

Simply connected region and primitives of analytic functions, Morera's theorem.

References

1. .Simmons -*Introduction to topology & Modern Analysis*
2. Munkesh- *Topology*
3. W.J Thron - *Topological Structires*
4. Joshi- *General Topology*
5. J. L. Kelly- *General Topology*

6. J. B. Conway - *Functions of one Complex Variable* Narosa]
7. R. B. Ash - *Complex Variable* . [A.P]
8. Punoswamy- *Functions of Complex Variable*
9. Gupta & Gupta- *Complex Variable*
10. W. Churchil- *Theory of Functional of Complex variable*
11. E.T. Copson- *Functions of Complex variable*
12. Philips- *Functions of Complex variable*

Paper- MCG104

(Ordinary Differential Equations & Special Functions, Operations Research-I)

Group- A

Ordinary Differential Equations & Special Functions

(Marks- 30)

Ordinary Differential Equations

First order system of Equations: Well-posed problems, Existence and uniqueness of the solution, simple illustrations. Peano's and Picard's theorems (statement only)

Linear systems, non-linear autonomous system, phase plane analysis, critical points, stability, Linearization, Liapunov stability, undamped pendulum, Applications to biological system and ecological system.

Special Functions

Series Solution : Ordinary point and singularity of a second order linear differential equation in the complex plane; Fuchs's theorem, solution about an ordinary point, solution of Hermite equation as an example; Regular singularity, Frobenius's method- solution about a regular singularity, solutions of hypergeometric, Legendre, Laguerre and Bessel's equations as examples.

Legendre polynomials: its generating functions; Rodrigue's formula, recurrence relations and differential equations satisfied by it; Its orthogonality, expansion of a function in a series of Legendre Polynomials.

Adjoint equations of n-th order: Lagrange's identity, solution of equation, from the solution of its adjoint equation, self-adjoint equation, Green's function.

Group- B

Operations Research- I (marks -20)

Introduction, Definition of O.R., Drawbacks in definition, Scope of O.R., O.R. and decision making, Application of O.R in different sectors, Computer application in O.R.

Fundamental theorem of L.P.P. along with the geometry in n- dimensional Euclidean space (hyperplane, separating and supporting plane).

Standard forms of revised simplex method, Computational procedure, Comparison of simplex method and revised simplex method, Sensitivity analysis, Bounded variable method, the Primal Dual Method.

Mathematical formulation of Assignment Problem, Optimality condition, Hungarian method, Maximization case in Assignment problem, Unbalanced Assignment problem, Restriction on Assignment, Travelling salesman problem.

References:

1. Wagner- *Principles of Operations Research* (PH)
2. Sasivevir, Yaspan, Friendman- *Operations Research: Methods and Problems* (JW)
3. J.K Sharma- *Operations Research- Theory and Applications*
4. Taha- *Operations Research*
5. Schaum's Outline Series- *Operations Research*
6. Hillie & Liberman- *Introducing to Operations Research*
7. Swarup, Gupta & Manmohan - *Operations Research*
8. J. C. Burkill- *The Theory of Ordinary Differential*
9. E. A. Codington and Levinson- *Theory of Ordinary Differential Equations* [TMH]
10. R. P. Agarwal & R.C Gupta - *Essentials of Ordinary differential Equations* [MGH]
12. G. Birkhoff & G. Rota- *Ordinary Differential Equation* [Ginn]
13. E. D. Rainville- *Special Functions* [Macmillan]
14. I. N. Sneddon- *Special Functions of mathematical Physics & Chemistry* [Oliver & Boyd, London]
15. N. N. Lebedev- *Special Functions and Their Applications* [PH]

Paper - MCG105
(Principle of Mechanics- I & Numerical Analysis)
Group- A
Principle of Mechanics - I (Marks-30)

Generalised co-ordinates: Degrees of freedom, Constraint, Principle of Virtual Work. Lagrangian formulation of Dynamics: Lagrange's equations of motion for holonomic and non- holonomic system. Ignorance of coordinates.

Routh's process for the ignorance of co-ordinates. Rayleigh's dissipation function. Calculus of variation and Euler- Lagrange differential equations. Brachistochrone problem. Configuration space and system point. Hamilton's principle; Hamilton's canonical equations of motion. Principle of energy.

Principle of least action, Canonical Transformations, Poisson Bracket.

Group- B Numerical Analysis (Marks-20)

Numerical Methods: Algorithm and Numerical stability.

Graeffe's root squaring method and Bairstow's method for the determination of the roots of a real polynomial equation.

Polynomial Approximation : Polynomial interpolation; Errors and minimizing errors; Tchebyshev polynomials; Piece-wise polynomial approximation. Cubic splines; Best uniform approximations, simple examples.

Richardson extrapolation and Romberg's integration method; Gauss' theory of quadrature. Evaluation of singular integral.

Operators and their inter-relationships: Shift, Forward, Backward, Central differences; Average operators, Differential operators and differential coefficients.

Initial Value Problems for First and Second order O.D.E. by

(i) 4th order R- K method

(ii) RKF₄-method

(iii) Predictor- Corrector method by Adam-Bashforth, Adam-Moulton and Milne's method.

Boundary value and Eigen-value problem for second order O.D.E. by finite difference method and shooting method.

Elliptic, parabolic and hyperbolic P.D.E (for two independent variables) by finite difference method; Concept of errors, convergence & numerical stability.

References :

1. F. Chorlton- *A text Book of Dynamic*
2. Synge and Griggith- *Principles of Mechanics*
3. D.T. Green Wood- *Classical Dynamics*
4. E. T Whittaker- *A Treatise on the Analytical Dynamics of Particile and Rigid Bodies*
5. K. C. Gupta - *Classical Mechanics of Particles and Rigid Bodies.*
6. F. Gantmacher- *Lectures in Analytical Mechanics*
7. H. Goldstein - *Classical Mechanics*
8. F. B. Hildebrad- *Introduction to Numerical Anslysis*
9. Demidovitch and Maron- *Computational Mathematics*
10. F. Scheid- *Computers and Programming (Schaum's series)*
11. G. D. Smith- *Numerical Solutionof Partial Dieeereential Equations (Oxford)*
12. Jain, Iyengar and Jain- *Numerical Methods for Scientific and Engineering Computation*
13. A. Gupta and S.C Basu- *Numerical Analysis*
14. Scarborough - *Numerical Analysis*
15. Atkinson- *Numerical Analysis*
16. Raulstan- *Numerical Analysis*

SEMESTER - II
Paper - MCG201
(Complex Analysis - II & Real Analysis -II)
Group -A
Complex Analysis- II (Marks- 30)

Open mapping theorem.

Singularities. Laurent's series expansion and classification of isolated singularities, essential singularities and Casorati Weierstrass's theorem. Cauchy's residue theorem and evaluation of improper integrals.

Argument principle, Rouché's theorem and its application.

Maximum modulus theorem.

Conformal mappings, Schwarz's Lemma and its consequence.

Introduction to Analytic continuation.

Group- B
Real Analysis- II (Marks- 20)

Lebesgue integral of a simple function, Lebesgue integral of a non-negative (bounded or unbounded) measurable function, Integrable functions and their simple properties, Lebesgue integral of functions of arbitrary sign, Integrable functions, basic properties of the integral, Integral of point wise limit of sequence of measurable functions- Monotone convergence theorem and its consequences, Fatou's lemma, Lebesgue dominated convergence theorem. Comparison of Lebesgue's integral and Riemann integral, Lebesgue criterion of Riemannian integrability.

Fourier series, Dirichlet's kernel, Riemann-Lebesgue theorem Pointwise convergence of Fourier series of functions of bounded variation.

Referene :

1. J. B. Conway- *Functions of one Complex Variable* [Narosa]
2. R. B. Ash- *Complex Variable* [A. P]
3. Punoswamy- *Functions of Complex Variable*
4. Gupta & Gupta - *Complex Variable*
5. I. P. Natanson- *Theory of Functions of a Real Variable*, Vol. I
6. C. Goffman- *Real Functions*
7. Burkil & Burkil - *Theory of Functions of a Real Variable*
8. Goldberg - *Real Analysis*
9. Royden- *Real Analysis*
10. Lahiri & Roy - *Theory of Functions of a Real Variable*
11. Apostol - *Reals Analysis*
12. Titvmarsh- *Theory of Functions*
13. Charles Schwarz- *Measure, Integration and Function Spaces.*

Paper- MCG202
(Partial Differential Equations & Differential Geometry)
Group -A
Partial Differential Equations (Marks-30)

General solution and complete integral of a partial differential equation; Singular solution; Integral surface passing through a curve and circumscribing a surface.

First order P.D.E. : Characteristics of a linear first order P.D.E.; Cauchy's problem; Solution of Non-linear first order P.D.E by Cauchy's method of characteristics; Charpit's method (application only).

Second order linear P. D.E : Classification, reduction to normal form; Solution of equations with constant coefficients by (i) factorization of operators, (ii) separation of variables; Solution of one-dimensional wave equation and diffusion equation; Solution of Laplace equation in Cylindrical and spherical polar co-ordinates. Formulation of Initial and Boundary Value Problem of P.D.E; Solution of Dirichlet's and Neumann's problem of Laplace's equation for a circle.

Group- B
Differential Geometry (Marks -20)

Reciprocal base system, Intrinsic derivative, Parallel vector field along a curve Space Curve, Serret– Frenet formula.

Metric tensor of the surface, angle between two curves lying on the surface, Geodesics on a surface, Its differential equation, Geodesic curvature of a surface curve, Tensor derivative.

First fundamental form of the surface, Gauss's formula and second fundamental form of the surface, Meusnier theorem and Euler's theorem.

References:

1. T. Amarnath– *Partial Differential Equation*
2. I. N. Sneddon– *Partial Differential Equation*
3. H. Goldstein– *Classical Mechanics*
4. P. Phoolan Prasad & R. Ravichandan– *Partial Differential Equations*
6. M. Postnikov– *Lectures in Geometry, Linear Algebra and Differential Geometry.*
7. U. C. De- *Differential Geometry of Curves and Surfaces in E3, Anamaya Publi.,2007.*
8. M. P. Do Carmo- *Differential Geometry of Curves and surfaces*
9. B. O'Neill- *Elementary Differential Geometry*
10. Rutter- *Geometry of Curves*
11. Andrew Pressely- *Elementary Differential Geometry*

Paper-MCG203
(Operations Research-II & Principle of Mechanics-II)
Group - A
Operations Research-II (Marks-30)

Deterministic Inventory control Models; Introduction, Classification of Inventories, Advantage of Carrying Inventory, Features of Inventory System, Deterministic inventory models including price breaks.

Standard form of Integer Programming, The concept of cutting plane, Gomory's all integer cutting plane method, Gomory's mixed integer method, Branch and bound method.

Processing of n jobs through two machines, The Algorithm, Processing of n jobs through m machines, Processing of two jobs through m machines.

Project scheduling by PERT/CPM: Introduction, Basic difference between PERT and CPM, Steps of PERT/CPM Techniques, PERT/CPM network Components and Precedence Relationships, Critical Path analysis, Probability in PERT analysis, Project Crashing, Time cost Trade-off-procedure, Updating of the Project, Resource Allocation.

Group- B
Principle of Mechanics- II (Marks- 20)

Theory of small oscillations. Normal co-ordinates. Euler's dynamical equations of motion of a rigid body about a fixed point. Torque free motion. Motion of a top on a perfectly rough floor. Stability of top motion. Motion of a particle relative to rotating earth. Foucault's pendulum.

Special Theory of Relativity: Postulates; Special Lorentz Transformation; Fitz-Gerald contraction and time-dilation.

Einstein's velocity addition theorem. Relativistic mechanics of a particle, Energy equation $E = mc^2$.

References :

1. F. Chorlton - *A Text Book of Dynamic*
2. Synge and Griffith- *Principles of Mechanics*
3. D.T. Green Wood - *Classical Dynamics*
4. E. T. Whittaker- *A Treatise on the Analytical Dynamics of Particles and Rigid Bodies*
5. K. C. Gupta - *Classical Mechanics of Particles and Rigid Bodies*
6. I. S. Sokolnikoff - *Mathematical Theory of Elasticity*
7. Merovitch - *A Treatise on dynamics.*
8. Wagner - *Principles of Operations Research* (PH)
9. Sasievir, Yaspan, Friedman - *Operations Research: Methods and Problems* (JW)
10. J. K. Sharma - *Operations Research- Theory and Applications*
11. Taha - *Operations Research*
12. Schaum's Outline Series - *Operations Research*
13. Hillie & Lieberman - *Introduction to Operations Research*
14. Swarup, Gupta & Manmohan - *Operations Research*

Paper - MCG204
(Computer Programming & Continuum Mechanics-I)
Group- A
Computer Programming (Marks-30)

Structured Programming in FORTRAN– 77; Subscripted variables, Type declaration, DIMENSION, DATA, COMMON, EQUIVALENCE, EXTERNAL statements. Function and subroutine sub– programs; Programs in FORTRAN–77

Programming in C: Introduction, Basic structures, Character set, Keywords, Identifiers, Constants, Variable-type declaration, Operators: Arithmetic, Relational, Logical, assignment, Increment, decrement, Conditional.

Operator precedence and associativity, Arithmetic expression, Evaluation and type conversion, Character reading and writing, Formatted input and output, Decision making (branching and looping)– Simple and nested IF,IF–ELSE, WHILE–Do, For. Arrays-one and two dimension, String handling with arrays–one and two dimension String handling with arrays– reading and writing, Concatenation, Comparison, String handling function, User defined functions.

Group -B
Continuum Mechanics- I (Marks -20)

Continuous media, Deformation, Lagrangian and Eulerian approach; Analysis of strain (infinitesimal theory);.

Analysis of stress; Invariants of stress and strain tensors. Principle of conservation of mass; Principle of balance of linear and angular momentum; Stress equation of motion. Necessity of constitutive equations. Hooke’s law of elasticity, displacement equation of motion. Newton’s law of viscosity (statement only).

References:

1. Ram Kumar – *Programming With Fortran – 77*
2. P. S. Grover – *Fortran –77/90*
3. Jain & Suri – *FORTTRAN – Programming Language including FORTRAN – 90.*
4. G. C. Layek, A. Samad and S.Pramanik– *Computer Fundamentals, Fortran – 77 and Numerical Problems including C. S. Chand & Co.*
5. Xavier, C. – *C Language and Numerical Methods*, (New Age International (P) Ltd. Pub.)
6. *Gottfried, B.S.– Programming with C* (TMH)
7. Balaguruswamy, E. – *Programming ANSI C* (TMH)
8. F. Scheid– *Computers and Programming* (Schaum’s series)
9. T. J. Chang – *Continuum Mechanics* (Prentice– Hall)
10. Truedell – *Continuum Mechanics* (Schaum Series)
11. Mollar– *theory of Relativity*
12. F. Gantmacher– *Lectures in Analytical Mechanics*
13. J. L. Bansal – *Viscous Fluid Dynamics* (Oxford)
14. R. N. Chatterjee – *Continuum Mechanics*
15. H. Goldstein – *Classical Mechanics*

Paper –MCGP205
Computer Aided Numerical Practical (Marks – 50)
(Numerical Practical Using FORETRAN – 77)
[Problem – 25, Viva – 10 & Sessional –15]
(Viva to be conducted on Paper – MCG105 (B) & MCG204 (A))

1. Inversion of a non-singular square matrix.
2. Solution of a system of linear equations by Gauss– Seidel method.
3. Integration by Romberg’s method.
4. Initial Value problems for first and second order O.D.E by
 - (i) Milne’s method (First order)
 - (ii) 4th order Runge– Kutta method (Second order)
5. Dominant Eigen – pair of a real matrix by power method (large and least).
6. B.V. P. for second order O. D. E by finite difference method and Shooting method.
7. Parabolic equation (in two variables) by two layer explicit formula and Crank– Nickolson– implicit formula.
8. Solution of one dimensional wave equation by finite difference method.

References :

1. Ram Kumar– *Programming With Fortran–77*
2. P. S. Grover – *Fortran – 77/90*
3. Jain & Suri – *FORTTRAN –77 Programminh Language including FORTRAN–90*
4. G. C. Layek, A. Samad and S. Pramanik – *Computer Fundamentals, Fortran – 77 and Numerical Problems including C, S. Chand & Co..*
5. Xavier, C. – *C Language and Numerical Methods, (New Age International (P) Ltd. Pub.)*
6. *Gottfried, B.S. – Programming with C (TMH)*
7. Balaguruswamy, E. – *Programming in ANSI C (TMH)*

SEMESTER -III
PURE MATHEMATICS STREAM
Paper – MPG301
(Modern Algebra-II & Set Theory-I)
Group -A
Modern Algebra- II (Marks- 30)

Groups : Direct product (internal and external), Group action on a set, Conjugacy classes and conjugacy class equation, p- groups, Cauchy’s theorem, converse of Lagrange’s theorem for finite commutative groups, Sylow theorems and applications, Normal series, solvable series, solvable and Nilpotent groups, Jordan-Holder Theorem, Finitely generated Abelian groups, Free Abelian groups.

Rings : Unique factorization domain; Factorization of polynomials over a field; Maximal Prime and primary ideal; Noetherian and Artinian Rings; Hilbert basis theorem.

References :

1. I. N. Herstein– *Topics In Algebrs* (Wiley Eastern Ltd, New Delhi)
2. M. Artin – *Algebra* (P.H.I).
3. P.M. Cohn – *Alegebra*. Vol. –I, II, & III. (john wiley & sons)
4. N. Jacobson– *Basic Algebra* Vol. I, II.
5. D. S. Malik, J. N. Mordeson & M.K. Sen – *Fundamentals of Abstract Algebra* (Mc.Graw– Hill, International Edition).
6. J. B. Eraleigh– *A first Course in Abstract Algebra* (Narosa)
7. M. Gray – *A Radical Approach to Algebra* (Addison Wesley Publishing Company).
8. Hungerford – Algebra.
9. S. Lang– Algebra.
10. N. H McCoy– The theory of Rings.
11. Burton – Ring Theory.
12. Gallian – Algebra.

Group – B
General Topology - I (Marks - 20)

Normal spaces, Urysohn’s lemma anf Tietze’s extension theorem.

Product spaces, embedding lemma, Tychonoff spaces and characterization of Tychonoff spaces as subspaces of cubes.

Nets, filters subnets and convergence.

Compactness, Compactness and continuity, countable compactness, sequential compactness, BW compactness and their relationship, Local compactness, Tychonoff theorem (on Product of Compact Spaces).

References :

1. J. Dugundji – *Topology* (Allayn and Bacon, 1966)
2. J. L. Kelly – *General Topology* (Van Nostrand, 1955)
3. J. R. Munkers – *Topology – A first Course* (Prentice-hall of India, 1978)
4. G. F Simmons – *Introduction to Topology and Modern Analysis* (McGraw- Hill, 1963)
5. W. J. Thron – *Topological Structures* (Holt Reinhurt and Winston, 1966)

Paper-MPG302
(Graph Theory & Set Theory- I)
Group -A
Graph Theory (Marks - 40)

Graph, Subgraph, Complement, Isomorphism, Walks, Paths, cycles, connected components, Cut vertices and cut edges, Distance, radius and center, Diameter, Degree sequence, Havel-Hakimi Theorem (Statement only)

Trees, Centres of trees, Spanning trees, Eulerian and Semi Eulerian Graphs. Hamiltonian Graphs, Travelling Salesman Problem.

Vertex and Edge connectivities, Blocks, Mengers Theorem. Clique Number, Independence number, Matching number, Vertex and edge conserving number, domination number, Ramsays's Theorem.

Chromatic number, Bipartite graph. Broke's Theorem, Mycielski Construction, Chromatic polynominal, edge colouring number, Konig Theorem.

Adjacency matrix, Incidence matrix, Cycle rank and co-cycle rank, Fundamental Cycles with respect to Spanning tree and Calyley's theorem on tree.

Planner graphs, statement of Kuratowski Theorem, Isomorphism properties fo Graphs, Eulers formula, 5 colour theorem. Statement of 4 colour theorem, Dual of a planar Graph. Directed Graph, Binary relations directed paths, fundamental Circuits in Digraphs, Adjacency matrix of a Diagraph.

References:

1. J. A. Bondy U. S .R. Murty – *Graph Theory with Applications* (Macmillan, 1976)
2. Nar Sing Deo – *Graph Theory* (Prentice- Hall, 1974)
3. F. Harary – *Graph Theoru* (Addison- Wesley, 1969)
4. K. R. Pathsarthy – *Basic Graph Theory* (TMH., 1994)

Group - B
Set Theory- I (Marks- 10)

Axiom of choice Zorn's Lemma, Hausdorff maximality principle, Well-ordering theorem and their equivalence, General Cartesian product of sets, Cardinal numbers and their ordering, Schroder- Bernstein theorem.

References:

1. K. Kuratowski – **Introduction** to set theory and Topology
2. E. Mendelson – *Introduction to Methematical Logic*
3. R. R. Stoll – *Set Theory and Logic*
4. I. M. Copi – *Symbolic Logic*
5. W . Sierpienski – *Cardinal and Ordinal Numbers*
6. A. G Hamilton– *Logic for Mathematics* (Cambridge University Press)

Paper – MPG303
(SetS Theory-II & Mathematical Logic, Functional Analysis- II)
Group - A
Set Theory-II & Mathematical Logic (Marks- 30)
Set Theory -II

Addition, multiplication and exponentiation of cardinal numbers, the cardinal numbers N_0 and C and their relation.

Totally ordered sets, order type, well-ordered sets, ordinal numbers, initial segments, ordering of ordinal numbers, addition and multiplication of ordinal numbers, sets of ordinal numbers, Transfinite induction.

Mathematical Logic

Statement calculus : Propositional connectives, statement form, truth functions, truth tables, Tautologies, contradiction, adequate sets of connectives.

Arguments : Proving validity rule of conditional proof. Formal statements calculus, Formal axiomatic theory, L. Deduction theorem.

Consequences. Quantifiers, Universal and existential; symbolizing everyday language.

References :

1. K. Kuratowski – *Introduction to Set Theory and Topology*
2. E. Memderson– *Introduction to Mathematical Logic*
3. R. R. Stoll – *Set Theory and Logic*
4. I. M Copi – *Symbolic Logic*
5. W. Sierpienski – *Cardinal and Ordinal Numbers*
6. A. G Hamiltom – *Logic for Mathematicians* (Cambridge University Press)

Group-B
Functional Analysis - II (Marks - 20)

Completion of Metric space. Equicontinuous family of Functions. Compactness in $C [0,1]$ (Arzela-Ascoli's Theorem). Convex sets in linear spaces.

Properties of normed linear spaces. Finite dimensional normed linear spaces. Riesz's Lemma, and its application in Branch Spaces. Convergence in Banach Spaces. Equivalent Norms and their properties.

Principle of Uniform Boundedness (Banach- Steinaus), Open Mapping theorem. Closed graph theorem., Extension of continuous linear mapping.

References :

1. Lusternik and Sovolev - *Functional Analysis*
2. A.H. Siddiqui - *Functional Analysis with applications*, TMG Publishing Co. Ltd, New Delhi.
3. K. K Jha - *Functional Analysis, Student's Friends*, 1986

4. Vulikh - *Functional Analysis*
5. G. Bachman & L. Narici - *Functional Analysis*, Academic press, 1966
6. A. E Taylor - *Functional Analysis*, John wiley and sons, New York, 1958
7. E. Kreyszing - *Introductory Functional Analysis with Applications*, Wiley Eastern, 1989
8. L. V. Kantorovich and G. P. Akilov - *Functional Analysis*, Pergamon Press, 1982
9. B. K Lahiri- *Elements of Functional Analysis*, The world Press Pvt. Ltd., Kolkata, 1994
10. G. F Simmons - *Introduction to Topology and Modern Analysis*, Mc Graw Hill, New York, 1963
11. B. V. Limaye - *Functional Analysis*, Wiley Eastern Ltd

Paper - MPS304
(Special Paper- I) (Marks-50)
A: Differential Geometry of Manifolds- I

Definition and examples of differential manifolds. Tangent spaces. Jacobian map. One parameter group of transformations. Lie derivatives. Immersions and imbedding. Distributions/.

Exterior algebra. Exterior derivative.

Topological groups. Lie groups and Lie Algebra. Product of two Liegroups. One parameter subgroups and exponential maps. Example of Liegroups. Homomorphism and Isomorphism. Lie transformation groups. General linear groups.

Principal fibre bundle. Linear frame bundle. Associated fibre bundle. Vector bundle. Tangent bundle. induced bundle. Bundle homomorphisms.

References:

1. R. S. Mishra, *A course in tensors with applications to Riemannian Geometry*, Pothishala (Pvt.) Ltd., 1965
2. R. S. Mishra, *Structures on differentiable manifold and their applications*, Chandrama Prakashan, Allahabad, 1984.
3. B. B. Sinha, *An Introduction to Modern Differential Geometry*, Kalyani Publishers, New Delhi, 1982
4. K. Yano and M. Kon, *Structure of Manifolds*, World Scientific Publishing Co. Pvt. Ltd., 1984.
5. U. C. De and A. A. Shaikh, *Differential Geometry of Manifolds*, Narosa Publishing House Pvt. Ltd., 2007

B: Advanced Real Analysis -I

Upper and lower limits of real function and their properties.

Pointwise differentiation of functions of linear intervals. Derivates and derivatives. Measurability of derivates. Differentiation of real functions. Dini derivates and their properties. Monotonicity theorem. Example of a continuous nowhere differentiable function.

Vital covering theorem in one dimension. Differentiability of monotone functions. Absolutely continuous functions and singular functions. Cantor ternary set and cantor function. Indefinite Lebesgue Intergral. Fundamental theorem of integral calculus for Lebesgue intergal. Lusin's condition (N). Characterization of absolutely continuous functions (Bansch-Zaricki theorem).

References:

1. Hewitt and Stormberg – *Real and Abstract Analysis*
2. H. L. Royden – *Real Analysis*
3. Saks – *Theory of Integrals*
4. W. Rudin – *Real and Abstract Analysis*
5. M. E. Munroe – *Measure and Integration*
6. I. P. Natanson – *Theory of Functions of a Real Variable, Vols. I & II*
7. E. W. Hobson – *Theory of Functions of a Real Variable, Vols. I & II*

C: Advanced Functional Analysis -I

Topological vector spaces, Local base and its properties, Separation properties, Locally compact topological vector space and its dimension. Convex Hull and representation Theorem, Extreme points, Symmetric sets, Balanced sets, absorbing sets, Bounded sets in topological vector space. Linear operators over topological vector space, Boundedness and continuity of Linear operators, Minkowski functionals, Hyperplanes, Separation of convex sets by Hyperplanes, Krein-Milman Theorem on extreme points.

Locally convex topological vector spaces, Criterion for normability, Seminorms, Generating family of seminorms in locally convex topological vector spaces. Barreled spaces and Bornological spaces, Criterion for Locally convex topological vector spaces to be (i) Barreled and (ii) Bornological.

Strict convexity and Uniform convexity of a Branch space. Uniform Convexity of a Hilbert Space. Reflexivity of uniformly convex Branch space, Weierstrass approximation theorem in $C[a,b]$

References:

1. W. Rudin – *Functional Analysis*, TMG Publishing Co. Ltd., New Delhi, 1973
2. A. A. Schaffer – *Topological Vector Spaces*, Springer 2nd Edn., 1991
3. G. Bachman & L. Narici – *Functional Analysis*, Academic Press, 1966
4. E. Kreyszing – *Introductory Functional Analysis with Applications*, Wiley Eastern, 1989

5. Diestel – *Application of Geometry of Banach Spaces*
6. Narici & Beckerstein – *Topological Vector spaces*, Marcel Dekker Inc, New York and Basel. 1985
7. G. F Simmons – *Introductiton to topology and Modern Analysis*, Mc, Graw Hill, New York, 1963
8. A. E. Taylor – *Functional Analysis*, John Wiley and Sons, NewYork 1958
9. Lipschitz – *General Tropology*, Schaum Series
10. K. Yosida – *Functional Analysis*, Spring Verlog, New York, 3rd Edn.,1990
11. Brown and Page – *Elements of Functional Analysis*, Von Nostrand Reinhold Publishing Co., 1970
12. Holmes – *Geometric Functional Analysis and its Application*
13. J. Horvorth – *Topological Vector spaces and Distributions*, Addison - Wesley Publishing Co., 1966
14. C. Goffman and G. Pedrick - *First Course in Functional Analysis*, PHI, New Delhi 1987
15. R. E Edwards *Functional Analysis*, Holt Rinchart and Wilson, New York, 1965
16. A Wilamsky – *Functional Analysis*, TMG Publishing Co. Ltd, New Delhi, 1973

D : Rings of Continuous Function I

The Ring $C(X)$ of the real valued continuous function on a topological space X , its subrings, the subring $C^*(X)$, their Lattice structure, ring homomorphisms and lattice homomorphism.

Zero- Sets cozero-sets, their unions and intersection, completely separateds sets, C^* - embedding, Urysohn's extension theorem and C -Embedding. Pseudocompactness and internal characterization of Pseudocompact spaces.

Ideals, Z - filters,maximal ideals, prime ideals, prime filters and their relation.

Completely regular spaces and the zero-sets, weak topologies determined by $C(X)$ and $C^*(X)$. Srone-Each's thorem concerning adequacy of tychonoff spaces X for investigation of $C(X)$ and $C^*(X)$, compact subsets and C - embedding, locally compact spaces and their properties.

Convergence of Z -filters, cluster points, Prime Z filters convergence and fixed Z -filters. Fixed ideals and compactness, fixed maximal ideals of $C(X)$ and $C^*(X)$, their characterizations, the residue class rings modulo fixed maximaln ideals in $C(X)$ and $C^*(X)$ and the field of reals. Relation between fixed maximal indeal in $C(X)$ and $C^*(X)$. Compactness and fuxed ideals.

P - spaces, P - points and their properties, characterization of P – spaces, properties of P – spaces.

References :

1. Richard E. Chandler, *Hausdorff Compactifications* (Marcel Dekker, Inc. 1976).
2. L. Gillmen and M. Jerison, *Rings of Continuous Functions* (Von Nostrand, 1960).
3. *Topological Structures* (Halt Reinhurt and Winston, 1966).

E. Theory of Rings And Algebras - I

Rings and Ideals :Definations, Ideal. Quotient rings and homomorphisms, The field of quotients, Minimal and maximal conditions, Primary decomposition, Polynomical rings. The Classical Radical : Nilpotent ideals and the radical, The radical of related rings, Artinian & Noethrian rings, Direct sum decompositions, Ideals in semisimple rings, Matrix rings, The Wedderburn theorem.

Modules : Preliminaries, Direct sums and free modules, projective modules, Tensor products, field and matrix representations, Algebras.

The Jacoson Radical : Primitive rings, The Density Theorem, Structure theorems.

References :

1. Mary Gray – *A Radical Approach to Algebra* (Addion- Wesley Publishing Company)
2. Ernst – August Behrems (Translared by Clive Reis) – *Ring heory* (Academic Press, New York, Berlin)
3. Stanley Burris & H. P Sankappanvar – *A course in Universal Algebra* (Springer-verlag, New York, Berlin)
4. L. H Rowen – *Ring Theory* (Academic Press)
5. T. Y. Lam – *Noncommucative Rings* (Springer -verlag0)
6. N. Jacolson – *Basic Alegebra – II*
7. I. N. Herstein – *Noncommutative Rings*
8. N. J Divisky – *Rings and Radicals*
9. N. H. Mc Coy – *The Theory of Rings*
10. M. R. Adhikari – *Groups, Rings, Modules and applications*

F. Non Linear Optimization in Banch Spaces - I

Review of Weak Convergence in normed spaces, reflexivity of Banach spaces, Hahn-Banch theorem and partially ordered linear spaces.

Existence Theorems for Minimal Points – Problem formulation.

Existence theorems. Set of minimal points.

Applications to approximations and optimal control problems. Generalised Dervatives- Directional derivative. Gateaux and Frechet derivatives. Subdifferential Quasiffifferential Clarke derivative.

References:

1. Johannes John – *Introduction to thes Theory of Nonlinear Optimization* (Springer-Verlag, 1994)
2. V. Bartu and T. Precupanu – *Convexity and Optimization in Banach Spaces* (Editura Acad. Bucuresti, 1986).
3. A. V. Balakrichnan – *Applied Functional Analysiss* ISpringed- Verlag)

G: Harmonic Analysis - I

Basic properties of topology groups, subgroups, quotient group and connected groups. Discussion of Haar Measure without proof on \mathbb{R} , \mathbb{T} , \mathbb{Z} , and some simple matrix groups. $L^1(\mathbb{G})$ and convolution with special emphasis on $L^1(\mathbb{R})$, $L^1(\mathbb{T})$, $L^1(\mathbb{Z})$. Approximate identities.

Fourier series. Fejer's theorem. The Classical kernels. Fejer's Poisson's and Dirichlet's summability in norm and point wise summability. Fatou's Theorem. The inequalities of Hausdorff and Young.

Examples of conjugate function series. The Fourier transform. Kernels of \mathbb{R} . The Plancherel theorem on \mathbb{R} Plancherel measure on \mathbb{R} . \mathbb{T} . \mathbb{Z} . Maximal ideal space of $L^1(\mathbb{R})$, $L^1(\mathbb{T})$ and $L^1(\mathbb{Z})$.

References :

1. Henry Helson – *Harmonic Analysis* (Hindustan Pub. Corp., 1994)
2. E. Hewitt and K. A. Ross – *Abstract Harmonic Analysis* Vol. I (Springer-Verlag, 1993)
3. Y. Katznelson – *An Introduction to Harmonic Analysis*, (John Wiley, 1968)
4. P. Koosis – *Introduction of H^p Spaces* (Cambridge Univ. Press)
5. R. R. Goldberg – *Fourier transforms*
6. T. Huissain – *Introduction topological groups*

H : Applied Functional Analysis -I

Review of Basic properties of Hilbert spaces. Convex programming supports functional of a convex set. Minkowski functional. Separation Theorem. Kuhn-Tucker Theorem. Minimax theorem. Farkas theorem.

Spectral theory of operators. Special Theory of compact operations. Operations on a separable Hilbert space. Krein factorization theorem for continuous kernels and its consequences. L_2 spaces over Hilbert spaces.

Multilinear forms. Analyticity Theorems. Non-linear Volterra operators.

References :

1. A.V. Balakrishnan – *Applied Functional Analysis*, Springer-Verlag.
2. Dunford and Schwartz – *Linear operators*, Vol. 1 & 11.
3. S. G. Kerin-Linear Differential Equations in a Banach space.
4. K. Yosida-Functional Analysis.

Paper - MPS305

(Special Paper- II) Marks - 50)

A: Measure and Integration - I

Algebra and σ -algebra of sets. Monotone class of sets. Borel sets.

σ and \mathcal{G} Sets. Countably additive set function. Measure on σ - algebra. Outer measure and measurability. Extension of measure spaces. Construction of outer measures. Regular

outer measure. Lebesgue Stieltjes measures and distribution function. Example of non-measurable sets. (Lebesgue).

Measurable functions. Approximation of measurable functions by simple functions. Egoroff's Theorem. Lusin's theorem. Convergence in measure. Integrals of simple functions. Integral of measurable functions. Properties of Integrals and Integrable functions. Monotone convergence theorem. Fatou's Lemma, Dominated convergence Theorem, Vitali convergence theorem.

Reference :

1. I. P. Rana – *Measure and Integration*
2. G. D Barra – *Measure and Intregation*
3. Hewitt and Stotnberg – *Real and abstract analysis*
4. H. L Royden – *Real Analysis*
5. Saks – *Theory of Integrals*
6. W. Rudin – *Real and Abstract Analysis*
7. M. E. Munroe – *Measure and Intregation*
8. Taylor – *Measure and Intregation*
9. I. P. Natanson – *Theory of Functions of a Real Variable* Vols. I & II
10. Charles Schwartz - *Measure, Integration and Function spaces*. World Scientific Publi., Singapore, 1994

B. Operator Theory And Application -I

Adjoint operators over normed linear spaces; their algebraic properties. Compact operators on normal linear spaces, Sequence of Compact operators, Compact extensions, Weakly compact-operators.

operator equation involving compact operators, Fredholm alternative; Adjoint operators on Hilbert-spaces, Self-adjoint operators, their algebraic properties; Unitary operators, normal operators in Hilbert spaces, positive operators, thier-sum, prouduct; Monotone sequence of positive operators, square-root of positive operator, Projection operators.

Their sum and product; Idempotent operators, positivity norms of Projection operators; Limit of monotone incresing sequence of Projection operators.

References :

1. G. Bachman & L. Narici - *Fundamental Analysis*, Academic Press, 1966
2. B. V. Limaye - *Functional Analysis* Wiley Easten Ltd
3. E. Kreyszig - *Introductory Functional Analysis with applications*, Wiley Eastern, 1989
4. B. K. Lahiri - *Elements of Functional Analysis* The World Press Pvt. Ltd., Kolkata 1994
5. G. F. Simmons- *Introduction to topology and Modern Analysis*, Mc. Graw Hill , New York, 1963
7. K. Yosida - *Functional Analysis*, Springer Verlog, New York, 3rd. Edm., 1990

8. Brown and Page - *Elements of Functional Analysis*, Von Nostrand Reinhold Co., 1970
9. A. E. Taylor - *Functional Analysis*, John Wiley and Sons, New York, 1958
10. L. V Kantorovich and G.P. Akilov - *Functional Analysis*, Pergamon Press, 1982
11. Vulikh - *Functional Analysis*
12. J. Tinsley Oden & Leszek F. Dorn - *Functional Analysis* CRC Press Inc, 1996
13. Lipschitz - *General Topology*, Schaum Series

C : Algebraic Topology - I

Homotopy : Definition and some examples of homotopies, homotopy type and homotopy equivalent spaces, retraction and deformation, H- space.

Category : Definitions and some examples of category, factor and natural transformation.

Fundamental Groups and covering spaces : Definition of the fundamental group of a space, the effect of a continuous mapping on the fundamental group, fundamental group of a product space, notion of covering spaces, lifting of paths to a covering space, fundamental group of a circle.

Universal cover, its existence, calculation of fundamental groups using covering space.

Projection space and tours, homomorphism and automorphisms of covering spaces, deck transformation group, Borsuk – Ulam theorem for S^2 , Brouwer fixed point theorem in dimension 2.

References:

1. W. S. Massey – *Algebraic Topology*
2. W. S. Massey – *Singular Homology Theory*
3. E. H. Spanier – *Algebraic Topology*
4. B. Gray – *Homotopy Theory An Introduction to Algebraic Topology*
5. C. R. Bredon – *Geometry and Topology*

D : Lattice Theory - I

Introduction : Partially ordered sets, graphs, order isomorphism, Maximal minimal condition, Jordan-Dedekind chain condition, dimension function.

Definition of an algebra, Lattices as algebras, density principle, Lattices as partially ordered sets sublattices ideals, complements, semicomplements, atoms, irreducible and prime elements. Morphisms homomorphisms, Ideals direct products.

Closure operation, Dedekind condition, Dedekind cuts. Completion, interval topology.

Distributive and modular lattices, modularity and distributive criterion, distributive sublattices of modular lattices, transposed intervals, meet representation in modular and distributive lattices/

References :

1. G. Szasz – *Lattice Theory*
2. G. Birkhoff – *Lattice Theory*
3. B. H. Arnold – *Logic and Boolean Algebra*
4. D. E. Rutherford – *Lattice Theory*

E : Advanced Operations Research - I

Non-linear Optimization : Local and global minima and maxima, convex functions and their properties, Method of Lagrange multiplier.

Optimality in absence of differentiability, Slater constraint qualification, Karlin's constraint qualification, Kuhn-Tuckers Saddle point optimality conditions, Optimality criterion with differentiability and convexity separation theorems, Kuhn-Tuckers sufficient optimality theorem.

Unconstrained Optimization : Search method : Fibonacci search, Golden Section search; Gradient Methods : Steepest descent Quasi-Newton's method, Davidon-Fletcher-Powell method, Conjugate direction method (Fletcher-Reeves method).

Quadratic Programming : Wolfe's Modified Simplex method, Beale's method.

Separable convex programming, Separable Programming Algorithm.

Network Flow : Max-flow min-cut theorem, Generalized Max Flow min-cut theorem, Linear Programming interpretation of max-flow min-cut theorem, minimum cost flows Minflow max-cut theorem.

References :

1. G. Hadly – *Non-Linear and Dynamic Programming*, Addison-Wesley, Reading Mass.
2. G. Hadly – *Linear Programming*, Narosa Publishing House.
3. S. S Rao – *Optimization theory and Applications*, Wiley Eastern Ltd., New Delhi
4. O. L. Mangasarian – *Non-Linear Programming*, McGraw Hill, New York.
5. Luenberger – *Introduction to Linear and Non-Linear Programming*
6. S. Dano : – *Non-Linear and Dynamic Programming*.
7. H. A. Taha – *Operations Research – An Introduction*, Macmillan Publishing Co., Inc., New York
8. Swarup Gupta & Manmohan – *Operations Research*, Sultan Chand & Sons, New Delhi
9. N. X. Kambo – *Mathematical Programming Techniques*, Affiliated East-West Press Pvt. Ltd., New Delhi
10. M. C Joshi and K. M. Moudgalaya, *Optimization theory and Practice*, Narosa Publishing House, New Delhi
11. C. R Bector, S. Chandra and J. Dutta, *Principles of optimization Methods*, Springer-Verlag.
12. M.A. Bhatti, *Practical optimization Methods*, Springer verlag.

C : Geometric Functional Analysis -I

Convexity in Linear spaces. Convex functions Basic separation Theorems. Convexity, and orderings. Alternate formulation of the the separation Principle. Some Application External sets. Locally convexity and Topology. Weak Topology.

References:

1. Holmes – *Geometric Functional Analysis and Its Applications*

G : Proximates, Nearness and Extensions of Topology Spaces -I

Eech closure operator closure spaces, symmetric Eech closure operator, continuity, homeomorphisms and their properties. Linkage compact topological spaces and their relation with compact topological spaces in presence of regularity condition. Extensions of closure spaces, trace system, principle (strict) Extensions, ordering of extensions. Representation of principal T_0 extension of a T_0 topological space with a given trace system. The set of principal T_0 extensions of a T_0 topological spaces is a partially ordered set and its consequence for the class of T_2 com pactification of a Tychonoff space.

(Basic) proximates, induced closure operators, proximity spaces, proximal neighbourhoods, p -continuous functions and their properties. Lattice structure of the basic proximities compatible with a symmetric closure space. Clams, clusters and relation between them. Basic proximities are clan generated structures. Classification of basic proximities : Riese (RI-) proximities , Lodato (LO-) proximities, Efremovie (EF-) proximities, their characterization and relation between them.

References :

1. S. A. Naimpully and B. D. Wanack – *Proximity Spaces* (Cambridge Track No. 59, Cambridge, 1970)
2. W. J Thron – *Topological Structure* (Halt Reinhurt and Winster, 1966)
3. E. Eech – *Topological Structures* (English Transl. Wiley. New York, 1966)

H : Advanced Complex Analysis - I

Analytic function, the function $M(r)$ and $A(r)$. Theorem of Borel and Caratheodary, Convex function and Handamard three-circle theorem, Phragmen-Lindelof theorem. Harmonic function Mean value property, Maximum principle, Harmonic functions on a disk, Hamaek's inequality, Dirichlet's problem.

Integral function, Poisson jenson formula, construction of an intergal functions with given zeros– Weierstrass theorem, Jensen's inequality, order, exponent of vonvergence of zeros of an integral function, canonical product, genus, Hadamard's factorization theorem, Borel's theorems, Picard's first second theorms.

References :

1. J. B. Conway – *Functions of One Complex Variable*
2. L. V. Ahlfors – *Complex Analysis*
3. W. Rudin – *Real and Complex analysis*

4. E. C. Titchmarsh – *Theory of Functions*
5. E. T. Copson – *Function of a Complex Variable*
6. R. P. Boas – *Entire Functions*
7. H. Cartan – *Analytic Functions*
8. A. I MARKudevich – *Theory of Functions of a Complex Variables*, Vol. I & II
9. M. Dutta and Lokenath Debnath – *Elliptic Functions*.

SEMESTER - III

APPLIED MATHEMATICS STREAM

Paper - MAG301

(Methods of Applied Mathematics - I)

Method of Applied Mathematics- I (Marks - 50)

Integral Transforms

Fourier Transform and its ,properties, Inversion formula of F. T.; Convolution Theorem; Parseval’s relation. Applications. Outline of Finite Fourier transform and its inversion formula.

laplace’s Transform and its properties. Invesion by analytic method and by Bromwitch path. Lerch’s Theorem. Convolution Theorem; Applications.

Integral Equations

Linear Integral Equation, Reduction of differential equation to integral equation, Existence, Uniqueness and iterative solution of Fredholm and Volterra Integral equations; examples, Solution of Fredholm integral equation for degenerate kernel; Examples, Faulting type (closed cycle type) integral equations, singular integral equation; Solution of Abel’s integram equation.

Generalised Functions

Generalised function; Elementary properties; Addition, Multiplication, Transformation of variables. Generalised function as the limit of a sequence of good functions, Differentiation of generalized function. Simple examples, Antiderivative, Regularisation of divergent intergal : Simple Example, Fourier Transform of generalised function, Examples, Convergence of a sequence of generalised functions ; Examples, Laplace transform of generalized function.

Operator Equations on Hilbert Spaces

Inner products spaces, Hilbert spaces; orthonormality; closedness, and completeness of sets. Fourier expansion, Reisz Fischer theorem. (proof not reqd). Isometric isomorphism between a separable Hilbert space and l_2 , Linear operators on Hilbert space, continuity,

boundedness, adjointness, self-adjointness, invertibility, boundedness and unboundedness of inverse. Compactness, illustrative examples. Eigen value problems, Special theorem for compact self-adjoint operators, Application to Regular Sturm-Liouville problem, Integral equations with Hilbert-Schmidt kernel, implications on Laplace operator. Solvability of operator equations, Fredholm alternatives.

References :

1. Gelfand & Shilov – *Generalised Functions* (Academic Press)
2. I. N. Sneddon – *Fourier Transforms* (MacGraw – Hill)
3. R. V. Churchill – *Operational Methods*
4. Lusternik & Sobolev – *Functional Analysis*
5. Erwin Lareyzy – *Introductory Functional Analysis with Applications*
6. S. G. Mikhlin – *Integral Equations* (Pergamon Press)
7. F. G. Tricomi – *Integral Equations* (Interscience Publishers)
8. WE. V. Lovit. – *Linear Integral Equations* (Dover Publishers)
9. F. John – *Partial Differential Equations*
10. Williams – *Partial Differential Equations*
11. Epstein – *Partial Differential Equations*
12. Chester – *Partial Differential Equations*
13. Arnold – *Ordinary Differential Equations*

Paper - MAG302

(Methods of Applied Mathematics - II, Theory of Electro Magnetic Fields)

Group - A

Methods of Applied Mathematics - II (Marks -30)

Linear ordinary differential equations; generalized solution, Fundamental solution, inverse of a differential operator. Two-point boundary value problem for a second-order linear O. D.E. Green's functions and its bilinear expansion, particular integral, Analogy between linear simultaneous algebraic equations and Linear differential equation.

Mathematical models and initial boundary value problems of 2nd order partial differential equation (PDE); wellposedness; necessity of classification and canonical forms Invariance of nature of an equation and its charecterstics under coordinate transformation; transformation of semilinear 2nd order PDE in two indepedent variables; linear transformations, and linear PDE's with more than two indepedent variables.

Linear hyperbolic PDE's in two independent variables Cauchy problem. Cauchy-Kowalasky theorem (statement only) reason for restriction on cauchy ground curve. Rieman-Green function. Domain of dependence and influence. Possible discontunuites of solutions ; d' Alemberts solution and meaning of generalized solution.

Linear parabolic equations : Heat equation in two independent variables, solution of Cauchy problem using Dirac Delta function and Fourier transform. maximum principle for initial

– boundary value (for Dirichlet boundary condition) problem, uniqueness and stability of solution.

Methods of Eigen function expansion and Green's function; Separation of variables, formulation of eigenvalue problems related to wave, heat and Laplace equations.

Linear elliptic equation : Laplace equation: boundary value problem of Dirichlet, Neumann and Robin. Green's formulas involving Laplacian; mean value theorem, maximum principle, uniqueness and stability of solutions; Dirichlet principle, Rayleigh-Ritz method.

Green's function for Dirichlet problem in Laplace eqn. its properties and methods of construction. Method of images. Method of conformal mapping for 2- dimensional problem with problem of a unit circle as an example Bilinear expansion for Green's function for heat equation by the method of Eigen function expansion and Bilinear expansion for Dirac Delta function.

References:

1. G . F. C Duff and D Naylor – *Differential equations of Applied Mathematics* (Wiley International)
2. Stakgold – *Greens Functions and Boundary Value Problems* (John Wiley & Sons.)
3. D. H. Griffet – *Applied Functional Analysis* (Ellis Horwood Ltd. John Wiley & Sons.)
4. V. S Vladimirov – *Equations of Mathematical Physics* (Marcel Dancer, Ins. N.Y.)
5. Tikhnov & Samarski – *Equations of Mathematical Physics*

Group - B

Theory of Electro Magnetic Fields (Marks - 20)

Empirical basis of Maxwell's Equations : Coulomb's law, Gauss' law, Electrostatic potential, Steady current, Equation of continuity of charge, Biot-Savart's law, Magnetic induction, Ampere's law, Faraday's law, Maxwell's equations for electromagnetic field and their empirical basis. Material equations, Conditions at an interface, Electromagnetic potential, Electromagnetic energy, Poynting theorem.

Application of Maxwell's Equations :

Plane electromagnetic Waves in vacuo, dielectric and conducting media, Group velocity and phase velocity, Retarded and accelerated potentials, Reflection and Refraction of plane waves at the plane boundary between two dielectrics, Field of a point charge in uniform motion.

References :

1. W.K. H Panofsky & M. Phillips– *Classical Electricity and Magnetism* (Addison - Wesley Pub. Co.Inc., 1962).
2. J. R. Reitz & F. J. Milford – *Foundations of Electromagnetic Theory* (Addison - Wesley Pub. Co., Inc 1966)
3. D. J. Griffith – *Classical Electrodynamics* (Wiley Eastern, 1965)

Paper - MAG303
(Continuum Mechanics - II, Dynamical Systems)
Group -A

Continuum Mechanics-II (Marks -30)

General : Body, configuration, axiom of continuity, Motion of a body. Reference configuration, deformation. Material and spatial coordinates. Material and spatial time derivatives – relation between them. Velocity and acceleration. Physical components of acceleration in general curvilinear coordinates– in cylindrical coordinates and spherical polar coordinates, Deformation gradient tensor, Reynolds transport theorem for volume property. Principle of conservation of mass– Path lines, stream lines and streak lines. Material surface. (Bounding surface). Lagrange's criterion for material surface, polar decomposition theorem (Statement), polar decomposition of deformation theorem(statement) polar decomposition gradient tensor – stretch and rotation tensors, principle stretches. Classical theory of infinitesimal deformations. Compatibility equations, Relative deformation gradient tensor, relative stretch tensors and relative rotation tensor. Rate-of-strain tensor-its principal values and invariants rate-of rotation tensor- vorticity vector; velocity gradient tensor, General principles of momenta balance; Euler's laws of motion. Body forces and contact forces. Cauchy's laws of motion : Stress equation of motion and symmetry of stress tensor for non-polar material. Energy balance – first and second laws of thermodynamics.

Constitutive equation (stress-strain relations) for isotropic elastic solid. Elastic moduli. Strain-energy function. Beltrami Michel compatibility equations for stresses. Equations of equilibrium and motion in terms of displacement. Fundamental boundary value problems of elasticity and uniqueness of their solution (statement only). Saint-Venant's principle – solution of simple problems. wave propagation in an infinite elastic medium, Waves of distortion and dilatation.

References :

1. Leigh, D.C. -Non-Linear Continuum Mechanics (MacGraw Hill)
2. Truesdell, C - Continuum Mechanics
3. Chung, T.J.- Continuum Mechanics (Prentice Hall)
4. Truesdell, C and Noll, W. -Encyclopaedia of Physics Vol III/ 3, 1965 (Ed. S. Flugge)
5. Sokolnikoff, I. S. - Mathematical Theory of Elasticity
6. Milne-Thomson, L.M.- Theoretical Hydrodynamics>
7. Pai, S.L - Viscous Flow Theory
8. Schlichting H - Boundary Layer Theory
9. Eriengen, A.C. - Non-linear Theory of Continuous Media (Mac Graw- Hill)
10. F. Chorlton - A Text Book of Fluid Mechanics
11. Kolin Keibel & Roze- Theoretical Hydrodynamics
12. Besand & Ramsey- Fluid Mechanics

13. J. Bansal -Viscous Flow Theory

Group -B

Dynamical Systems (Marks : 20)

Dynamical Systems : Phase variables and phase space, continuous and discrete time systems flows (vector fields), maps (discrete dynamical systems), orbits asymptotic states, fixed (equilibrium) points periodic points, concepts of stability and SDIC (sensitive dependence of initial conditions) chaotic behaviour , dynamical system as a group.

Linear systems : Fundamental theorem and its applications. Properties of exponential of a matrix, generalized eigenvectors of a matrix, nilpotent matrix, stable, unstable and center subspaces, hyperbolicity, contracting and expanding behaviour.

Nonlinear Vector Fields : Stability characteristics of an equilibrium point. Liapunov and asymptotic stability. Souce, sink, basin of attraction. Phase plane analysis of simple system, homoclinic and heteroclinic orbits, hyperbolicity, statement of Hartmann-Gorbnam theorem and stable manifold theorem and their implications.

Liapunov function and liapunov theorem. Periodic solutions limit cycles and their stability concepts. Statement of Lienard's theorem and its application to vander Pol equation, Poineare Bendixsom theorem (statement and applications only) structural stability and bifurcation through examples of saddle-node, pitchfork and Hopf bifurcations.

References :

1. P. Gledinning – *Stability, Instability and Chaos* (Cambridge University Press 1994)
2. Strogartz – *Non-linear Dynamics*
3. M. W. Hirsch & Smale – *Differential Equations, Dynamical System and Linear Algebra* IAcademic Press 1974)
4. L. Perko – *Differential Equations and Dynamical System* (Springer – 1991)
5. Arnold – *Ordinary Differential Equations*.

Paper - MAS304

(Special Paper-I) Marks: 50

A: Viscous Flows, Boundary Layer Theory and Magneto Hydrodynamics-I

Viscous Flows

Some exact solutions of Navier - Stokes' Equations: the flow due to suddenly accelerated plane wall; the flow near an oscillating plane wall; plane stagnation point flow (Hiemenz flow); the flow near a rotating disk; Hele-shaw flow; Bodewadt flow.

Navier-Stokes equations in non-dimensional form; Reynolds number. Creeping motion; hydrodynamical theory of lubrication; Stokes's flow past a sphere and a cylinder : Stokes paradox; Oseen approximation, Oseen's solution for a sphere.

Laminar Boundary Layer Theory

Concept of boundary layer : Prandtl's assumptions. Two dimensional B.L. Equations for flow over a plane wall : Boundary layer on a flat plate ; Blasius-Topfer solution, 'Similar solutions' of the B. L. equations : B. L. flow past a wedge; B. L. flow along the wall of a convergent channel; B. L. flow past a circular cylinder;

Separation of boundary layer.

The spread of a jet :

- (i) plane free jet (two-dimensional jet),
- (ii) circular jet (axisymmetric jet).

Prandtl-Mises transformation :

Karman momentum integral equation. Karman - Pohlhausen method : simple applications.

References :

1. S. W. Yuan: Foundations of Fluid Mechanics, PHI, 1969
2. H. Schlichting: Boundary Layer Theory, Mc Graw-Hill Book Comp., 2004.
3. L.D. Landau and E. M. Lifshitz: Fluid Mechanics, Pergamon Press, 1959.
4. J. L. Bansal : Viscous Fluid Dynamics, 2003.
5. J. A. Shercliff : A text Book of Magnetrohydrodynamics.
6. V. C. A. Ferraro and C. Plumpton : An Introduction to magneto fluid Mechanics, Oxford Univ. Press, 1961.

B: Elasticity-I

1. Generalised Hooke's law Orthotropic and transversely isotropic media. Stress-strain relations in isotropic elastic solid.
2. Saint-Venant's semi-inverse method of solution (Statement). Formulation of torsion problem and the equations satisfied by the torsion function and the boundary condition. Formulation of torsion problem as an internal Neumann problem, Dirichlet's problem and Poisson's problem. Prandtl's stress function shearing stress in torsion problem. Solution of torsion problem for simple sections Method of sol. of torsion problem by conformal mapping.
3. Flexure problem : Reduction of flexure problem to Neumann problem. Solution of flexure problem for simple sections.
4. Potential energy of deformation. Reciprocal theorem of Betti and Rayleigh. Theorem of min. Potential energy. (10L)
5. Plane problem : plane strain, plane stress, generalised plane stress. Basic equations. Airy's stress function. Solution in terms of complex analytic function.

References :

1. Y. A. Amenzade - *Theory of Elasticity* (MIR Pub.)
2. A. E. H. Love - *A treatise on the Mathematical Theory of Elasticity*, CUP, 1963.

3. I. S. Sokolnikoff - *Mathematical Theory of Elasticity*. Tata Mc Graw Hill Co., 1977.
4. W. Nowacki - *Thermoelasticity* (Addison Wesley)
5. Y. C. Fung - *Foundations of Solid Mechanics*, PHI, 1965.
6. S. Timoshenk and N. Goodies, *Theory of Elasticity*, Mc Grwa Hill Co., 1970.
7. N. I. Muskhelishvili - *Some Basic Problems of the mathematical theory of Elasticity*, P. Noordhoff Ltd., 1963.

C: Elasticity and Theoretical Seismology-I

Elasticity

Generalised Hooke's law. Transversely isotropic media. Stress-strain relations in isotropic media.

Saint-Venant's semi-inverse method of solution. Torsion problem. Equation satisfied by torsion function and the boundary condition. Prandtl's stress function. Max shearing stress. Solution of torsion problem for simple sections.

Flexure problem. Differential Equation and the boundary condition. Solution for simple sections.

Potential energy of deformation. Reciprocal theorem of Betti and Rayleigh. Theorem of minimum potential energy.

Plane strain, plane stress. Basic equations. Airy's stress function. Thermo-elasticity : Thermal stress. Stress-strain relation in Thermo-elasticity.

References :

1. Y. A. Amenzade - *Theory of Elasticity* (MIR Pub.)
2. A. E. H. Love - *A treatise on the Mathematical Theory of Elasticity*, CUP, 1963.
3. I. S. Sokolnikoff - *Mathematical Theory of Elasticity*. Tata Mc Graw Hill Co., 1977.
4. W. Nowacki - *Thermoelasticity* (Addison Wesley)
5. Y. C. Fung - *Foundations of Solid Mechanics*, PHI, 1965.
6. S. Timoshenk and N. Goodies, *Theory of Elasticity*, Mc Grwa Hill Co., 1970.
7. N. I. Muskhelishvili - *Some Basic Problems of the mathematical theory of Elasticity*, P. Noordhoff Ltd., 1963.

D: Applied Functional Analysis-I

Review of basic properties of Hilbert spaces. Convex programming-support functional of a convex set. Minkowski functional. Separation Theorem. Kuhn-Tucker Theorem. Minimax theorem. Farkas theorem.

Spectral theory of operators. Spectral Theory of compact operations. Operators on a

separable Hilbert space. Krein factorization theorem for continuous kernels and its consequences. L_2 spaces over Hilbert spaces.

Multilinear forms. Analyticity Theorems. Non-linear Volterra operators.

References :

1. A. V. Balakrishnan- *Applied Functional Analysis*, Springer-Verlag.
2. Dunford and Schwartz-*Linear operators*, vol. 1 & 11.
3. S. G. Krein-Linear Differential Equations in a Branch space.
4. K. Yosida-Functional Analysis.

Paper - MAS305
(Special Paper-II) (Marks: 50)
A: Quantum Mechanics-I

1. Transformation Theory : Adjoint operator, Hermitian operator, Projection operator, Degeneracy, Unitary transformation, Matrix representation of wave functions and operators, Change of basis, Transformation of matrix elements, Dirac's Bra and Ket notation, Completeness and normalization of eigen functions, Common set of eigen functions of two operators, Compatibility of observables.
2. Symmetries and Invariance : Angular momentum eigenvalues and eigenfunctions, Spin, Addition of two angular momenta, Rotation groups, Identical particles, Pauli exclusion principle, Invariance and conservation theorems.
3. Relativistic Kinematics : Klein-Gordon equation, Dirac equation for a free particle and its Lorentz covariance, Hole theory and positron, Electron spin and magnetic moment.
4. Approximation Methods (time-independent)
Rayleigh-Schrodinger perturbation method, An harmonic oscillator, Stark effect in hydrogen atom, Zeeman effect, Ground state energy of helium atom.
5. Elements of Second Quantization of A System : Creation and Annihilation operator, Commutation and Anti-commutation rules, Relation with Statistics - Bosons and Fermions.

References :

1. A. Messiah - *Quantum Mechanics*, Vol. I & II (North - Holland Pub. Co., 1962).
2. B. H. Bransden & C. J. Joachain - *Introduction to Quantum Mechanics* (Oxford University Press, 1989).
3. P. G. Burke - *Potential Scattering in Atomic Physics* (Plenum Press, New York, 1977)
4. C. J. Joachain - *Quantum Collision Theory* (North-Holland Pub. Co., 1975)
5. B. H. Bransden - *Atomic Collision Theory* (W. A. Benjamin Inc., N. Y., 1970)

6. S. Geltman - *Topics in Atomic Collision Theory* (Academic Press. 1969)
7. T. Y. Wu and T. Olmura - *Quantum Theory of Scattering* (Prentice Hall, New Jersey, 1962)
8. N. F. Mott & H. S. W. Massey - *Theory of Atomic collisions* (3rd ed.), (Clarendon Press, Oxford, 1965)
9. M. L. Goldberger & K. M. Watson - *Collision Theory* (Wiley, N. Y., 1964)
10. R. G. Newton - *Scattering Theory of Waves and Particles* (McGraw - Hill, 1966)

B: Advanced Operations Research-I

Non-linear Optimization : Local and global minima and maxima, convex functions and their properties, Method of Lagrange multiplier.

Optimality in absence of differentiability, Slater constraint qualification, Karlin's constraint qualification, Kuhn-Tuckers Saddle point optimality conditions. Optimality criterion with differentiability and convexity, separation theorems, Kuhn-Tuckers sufficient optimality theorem.

Unconstrained Optimization : Search method : Fibonacci search, Golden Section search, Gradient Methods : Steepest descent Quasi-Newton's method, Davidon-Fletcher-Powell method, Conjugate direction method (Fletcher-Reeves method).

Optimality conditions : Kuhn-Tucker conditions - non negative constraints.

Quadratic Programming : Wolfe's Modified Simplex method, Beale's method.

Separable convex programming, Separable Programming Algorithm.

Network Flow : Max-flow min-cut theorem, Generalized Max flow min-cut theorem, Linear Programming interpretation of Max-flow min-cut theorem, Minimum cost flows, Minflow max-cut theorem.

References :

1. G. Hadly - *Non-Linear and Dynamic Programming*. Addison-Wesley, Reading Mass.
2. G. Hadly - *Linear Programming*, Narosa Publishing House.
3. S. S. Rao - *Optimization theory and Applications*. Wiley Eastern Ltd., New Delhi.
4. O. L. Mangasarian - *Non-Linear Programming*, Mc Graw Hill, New York.
5. Luenberger - *Introduction to Linear and Non-Linear Programming*.
6. S. Dano - *Non-Linear and Dynamic Programming*.
7. H. A. Taha - *Operations Research - An Introduction*, Macmillan Publishing Co., Inc., New York.
8. Swarup, Gupta & Manmohan - *Operations Research*, Sultan Chand & Sons, New Delhi.
9. N.S. Kambo- *Mathematical Programming Techniques*, Affiliated East-West Press Pvt. Ltd., New Delhi
10. M. C. Joshi and K.M. Moudgalya, *Optimization theory and Practice*, Narosa Publishing House, New Delhi

11. C.R. Bector, S. Chandra and J. Dutta, Principles of optimization Theory, Narosa Publishing House, New Delhi
12. M. A. Bhatti, Practical Optimization Methods, Springer Verlag

C: Inviscid Compressible Flows and Turbulence-I

Basic thermodynamics Equations of state; Polytropic gases. Euler's equations of Motion; Conservation of energy. Circulation theorem; propagation of a small disturbance : Sound waves. Steady isentropic motion : Bernoulli's eqn. Subsonic and supersonic flows. Irrotational flow : velocity potential ; Bernoulli's eqn. for unsteady flow : Stream function for steady two-dimensional motion. Steady flows through stream tubes, De Laval Nozzle. Method of characteristics, unsteady one -dimensional flow. Normal and oblique Shock relations; Shock polar diagram.

Exact solution for two-dimensional Steady motions : Radial flow : vortex flow , Prandtl-Meyer flows. Hodograph method : Molenbroek transformation; Legendre transformation ; Solution of Chaplygin's equation. Limit lines ; Linearization by the method of small perturbation : Prandtl - Glauert transformation. Subsonic and supersonic flow past thin bodies. Rayleigh Janzen's method for flow past a circular cylinder.

References :

1. S.W. Yuam : Foundations of Fluid Mechanics, PHI, 1969
2. H. Schlichtings : Boundary Layer Theory, Mc Graw-Hill Book Comp., 2004.
3. L.D. Landau and E.M Lifshitz : Fluid Mechanics, Pergamon Press, 1959,
4. J.L Bansal : Viscous Fluid Dynamics, 2003.
5. J.A. Shercliff : A text Book of Magnetrohydrodynamics
6. V.C.A Ferraro and C.Plumpton : An Introduction to magneto fluid Mechanics, Oxfrd Univ. Press, 1961.

D: Computational Fluid Dynamics-I

Finite Difference methods : Solutions of O.D.E., The method of factorization, iterative methods, upwind corrected schemes, Hermitian method . Solution of a one-dimensional linear parabolic equation; Noncentered schemes, Leapfrog Dufort- Frankel scheme, Solution of one dimensional Non-linear parabolic and hyperbolic equations, Explicit and Implicit methods, The Adi method, Explicit splitting method for two dimensional equation.

Finite Element Methods : Variational formulation of operator equations and Galerkin's method, the construction of the finite elements, Convergence rates for F.E.M., Stability of F.E.M Elementary ideas of Finite Volume method, Spectral method some simple applications of Fluid Dynamics Problems.

References :

1. Peter Linz- Theoretical Numerical Analysis, A Introduction to Advance Technique (Jhon Wiley and Sons.)
2. R. Peyret and T.D Taylor- Computational Methods for fluid flow (Springer-

- Verlag)
3. P. Wesseling - Principles of Computational Fluid Dynamics (Springer-Verlag,2000)
 4. J.D Anderson - Computational Fluid Dynamics : The Basics With Applications (Mc Graw- Hill, 1998)
 5. C.A.J Fletcher - Computational Techniques for Fluid Dynamics, Vol. I and II (Springer- Verlag).
 6. Dale A. Anderson, Jhon C . Tanehill, Richard H. Pletcher- Computational Fluid Mechanics and Heat Transfer (Hemisphere Publishing Corporation)

SEMESTER-IV
APPLIED MATHEMATICS STREAM
Paper - MAG401
(Continuum Mechanics-III) (Marks: 50)

Inviscid incompressible fluid : Definitions, Constitutive equation for inviscid fluid Euler's equation of motion- vector in variant form Steady motion - Bernoulli's equation and other consequences. Euler's momentum theorem; D' Alembert's paradox Helmholtz equation for vorticity circulation . Kelvin's theorem on circulation. Irrotational motion, velocity potential acyclic irrotational motion, velocity potential acyclic irrotational motion. permanence of irrotational motion some properties of acyclic irrotational motion (using Green,s theorem) and Uniqueness> General equation for impulsive motion and properties of motion under surface impulse Kelvin,s minimum energy theorem. Three dimensional source sink and doublet (definitions only). Two dimensional motion Stream function. Complex potential. Circular link vortex. Complex potential for line source (sink), line doublet and line vortex. Circle theorem. Method of Images. Blasius theorem for thrust on an obstacle-applications to circular cylindrical boundary. Flow past a circular cylinder with circulation : Kutta Joukowski, lift formula. Axi-symmetric motion. Stokes Stream function. Vortex motion vortex surface, vortex tube and vortex filament. Fundamental properties (Helmholtz properties) of vortex motion. Velocity field due to a distribution of Vorticity velocity field due to a closed vortex filament.

Gravity waves (Water waves) Surface condition, Cisott,s equation for complex potential of small height gravity waves. Progressive waves- cases of deep and shallow water. Stationary waves- possible wavelengths in a rectangular tank. Paths of particles for different waves. Energy for progressive Waves and Stationary wave. Group velocity and its dynamical significance.

Linearly viscous incompressible fluid :

Constitutive equations (stress-rate of strain relations) for linearly viscous fluid. Navier Stokes equations-vector invariant from Boundary conditions. Helmholtz equations for

diffusion of vorticity Dissipation of energy. Non-dimensional form of N.S. equations, Principle of similitude. Reynoldsnumber simple exact soluttions of N-s equations: Paral-
 lel flow, Generalized Couette flow plane. plane Poiseuille flow and simple Couette flow.
 Hagen Poiseule flow through a circular pipe. Viscomet ric flow Couettee circular motion.

References :

1. Leigh, D.C. -Non-Linear Continuum Mechantics (MacGraw Hill)
2. Truesdell, C - Continuum Mechanics
3. Chung, T.J.- Continuum Mechanics (Prentice Hall)
4. Trusdell, C and Nol, W. -Encyclopaedha of Physics Vol III/ 3, 1965 (Ed. S. Flugge)
5. Sokolnikoff, I. S. - Mathematical Theory of Elasticity
6. Miline- Thomson, L.M.- Theroretical Hydrodynamics>
7. Pai, S.L - Viscous Flow Theory
8. Schlichting H - Boundary Layer Theory
9. Eriengen, A.C. - Non-linear Theory of Continuous Media (Mac Graw- Hill)
10. F. chorlton - A Text Book of Fluid Mechanics
11. Kolin Kebel & Roze- Theroretical Hydrodynamics
12. Besand & Ramsey- Fluid Mechanics
13. J. Bansal -Viscous Flow Theory
14. Leigh, D. C.- Non- Linear Continuum Mechanics (Mac Graw Hill)
15. truesdell, C - Continuum Mechanics
16. Chung, T.J.- Continuum Mechanics (Prentice-Hall)
17. Trusdell, C and Nol, W- Encyclopaedia of Physics. Vol. III/ 3, 1965 (Ed.S. Flugge)
18. Sokolnikoff,Is.- Mathematical Theory of Elasticity
19. Miline - Thomson, L.M. -Theoretical Hydrodynamics
20. Pai, S.I. - Viscous Flow Theory
21. Schlichting H- Boundary Layer Theory.

Paper - MAG402

(Elements of Quantum Mechanics, Chaos and Fractals)

Group-A

Elements of Quantum Mechanics (Marks: 30)

1. Origin of the Quantum Theory :
 Black-body radiation, Indequacy of clasical theory, The old quantum theory, Bohr Sommerfeld theory, Atomic Spectra, Photoelectric effect and Compton effect, Matter waves, Wave-particle duality, Electron diffraction experiment.
2. Basic Concepts :

Wave function of a free particle, Uncertainty and Complementarity principles, Gedanken experiments, wave packet, Schrodinger wave equation, Statistical interpretation of the wave function, Formal solution of the Schrodinger Equation.

3. Simple Applications (exact solutions) :

One dimensional potential step, Potential barrier , Square well Potential, Linear harmonic oscillator, Three dimensional box potential, Spherically Symmetric potential, Hydrogen atom bound state problems.

4. Dynamical Variables and Operators :

Operators corresponding to physical observables, Expectation values of observables, The virial theorem, Eigenfunction and eigenvalues of operators, Discrete and continuous spectra Commutativity of operators, Heisenberg's Uncertainty relations, The minimum uncertainty product, Heisenberg's equation of motion for operators

References :

1. Heisenberg - The Physical Principles of the Quantum Theory [Dover Pub., 1930]
2. P. A. M. Dirac - The Principles of Quantum Mechanics [Oxford University Press, 1981]
3. F. Mandl - Quantum Mechanics [Butterworths Sci. Pub., London, 1957]
4. P. T. Mathews - Introduction to Quantum Mechanics [MacGraw Hill, 1963]
5. L. I. Schiff - Quantum Mechanics [MacGraw Hill, 1968]

Group-B

Chaos and Fractals (Marks - 20)

Chaos And Fractals : Examples, graphical analysis, orbits, phase diagrams fixed and periodic points stable and unstable sets smooth maps and conditions for stable and unstable periodic points hyperbolicity.

SDIC, topological transitivity (mixing) and Devaney's definition of chaos, binary decimal representation of numbers and saw tooth map. One parameter family of maps and bifurcations (through examples only) topological conjugacy, Logistic map, period doubling route to chaos.

Cantor sets, examples of fractals, definitions of topological and capacity dimensions, Horse shoe and the theorem : "period 3 implies chaos".

References :

1. P. Glendinning - Stability, Instability and Chaos (Cambridge University Press 1994).
2. Strogatz - Non-linear Dynamics
3. R. L. Devaney - A First Course In Chaotic Dynamical Systems.
4. R. A. Holmgren - A First Course In Discrete Dynamical Systems (Springer, 1991)
5. R. L. Devaney - An Introduction To Chaotic Dynamical System (Addison-Wesley 1987)
6. H. O. Peitgen - Fractals and Chaos.

Paper - MAS403
(Special Paper-III) Marks: 50
A: Viscous Flows, Boundary Layer Theory & Magneto-Hydrodynamics-II

Electromagnetic equations for moving media, Ohm's law including Hall current, Lorentz force. MHD approximations. Stress-tensor formulation of Lorentz force; frozen-in-magnetic field, Alfven's Theorem; Alfven waves. Equations of motions and induction; their nondimensional forms; dimensionless parameters, Lundquist's criterion. Energy equation: Viscous and joule dissipation, Poynting theorem. Boundary conditions.

Steady viscous incompressible flows: unidirectional flow under a transverse magnetic field: decoupling of MHD equations. Hartmann flow; Couette flow. Flow through a rectangular duct. Unsteady incompressible flows. Rayleigh's problem. MHD waves: propagation of small disturbances; plane waves; Reflection and transmission of plane harmonic waves; existence of finite amplitude MHD waves. Alfven waves with ohmic damping; skin effect.

Magnetohydrostatics; equilibrium-configurations, pinch effect, force-free fields, non-existence of force-free field of finite extent. General solutions for a force-free field, special cases.

Dynamo problem, Cowling's theorem, Ferraro's law of isorotation.

References:

1. S. W. Yuan: Foundations of Fluid Mechanics, PHI, 1969
2. H. Schlichting: Boundary Layer Theory, Mc Graw-Hill Book Comp., 2004.
3. L. D. Landau and E. M. Lifshitz: Fluid Mechanics, Pergamon Press, 1959.
4. J. L. Bansal: Viscous Fluid Dynamics, 2003.
5. J. A. Shercliff: A Text Book Of Magnetohydrodynamics
6. V. C. A. Ferraro and C. Plumpton: An Introduction to magneto fluid Mechanics, Oxford Univ. Press, 1961.

B: Elasticity-II

Vibrations problems: Longitudinal vibration of thin rods, Torsional vibration of a solid circular cylinder and a solid sphere. Free Rayleigh and Love waves.

Thermoelasticity: Stress-strain relations in Thermo elasticity. Reductions of static thermoelastic problem to a problem of isothermal elasticity. Basic equations in dynamic thermo elasticity. Coupling of strain and temperature fields.

Magneto-elasticity: Interaction between mechanical and magnetic field Basic equations Linearisation of the equations.

References:

1. Y. A. Amenzade - Theory of Elasticity (MIR Pub.)
2. A. E. H. Love - A treatise on the Mathematical Theory of Elasticity, CUP, 1963.
3. I. S. Sokolnikoff - Mathematical Theory of Elasticity, Tata Mc. Graw Hill Co, 1977.
4. W. Nowacki - Thermoelasticity (Addison Westey)
5. Y. C. Fung - Foundations of Solid Mechanics, PHI, 1965.

6. S. Timoshenk and N. Goodies, Theory of Elasticity, Mc Grwa Hill Co., 1970.
7. N. I. Muskhelishvili - Some Basic Problems of the mathematical theory of Elasticity, P. Noordhoff Ltd., 1963.

C: Elasticity and Theoretical Seismology-II

Theoretical Seismology

Theory of elastic waves; Motion of a surface of discontinuity - Kinematical conditions and dynamical conditions. Kirchoff's solutions of inhomogeneous wave equation.

Reflections and refractions of elastic body waves.

Surface waves : Rayleigh, Love and Stonely waves.

Dispersion and Group Velocity of elastic body waves.

Some problems : Application of pressure and twist on the walls of a spherical cavity in an elastic medium.

Line source and point source on the surface of a semi-infinite elastic medium.

References :

1. Y. A. Amenzade - Theory of Elasticity (MIR Pub.)
2. A. E. H. Love - A treatise on the Mathematical Theory of Elasticity, CUP, 1963.
3. I. S. Sokolnioff - Mathematical Theory of Elasticity, Tata Mc Grand Hill Co., 1977.
4. W. Nowacki - Thermoelasticity (Addison Wesley)
5. Y. C. Fung - Foundations of Solid Mechanics, PHI, 1965.
6. S. Timoshenk and N. Goodies, Theory of Elasticity, Mc Grwa Hill Co., 1970
7. N. I. Muskhelishvili - Some Basic Problems of the mathematical theory of Elasticity, P. Noordhooff Ltd., 1963.
8. E. Savarensky - Seismic wave, MIR Pub.
9. B. L. N. Kennett, Seismic wave propagation in Stratified Media, CUP
10. K. E. Bullen, An Introduction to the theory of Seismic waves and Sources, Springer-Verlag.

D : Applied Functional Analysis-II

Semigroups of linear operators-general properties of semigroups. Generation of semigroups. Compact semigroups.

Holomorphic semigroups, Elementary examples of semigroups. Extensions Differential Equations. Cauchy Problem, Controllability. State reductions. Ovservability. Stability and stabilizability. Evolution equations.

Optimal Control Theory-Linear quadratic regulator problem. The same problem with infinite time interval. Hard constraints Final value control. Time optimal control problems.

References :

1. A. V. Balakrishnan-Applied Functional Analysis, Springer Verlag.
2. Dunford and Schwartz-Linear ooperators, vol. 1 & 11.
3. S. G. Krein-Linear Differential Equations in a Branch space.
4. K. Yoasida-Functionnal Analysis.

Paper-MAS404
(Special Paper - IV) (Marks - 50)
A : Quantum Mechanics -II

Collision Theory : Basic concepts, Cross sections, Laboratory and center-of-mass coordinates, Rutherford scattering, Quantum mechanical formulation - time independent and time-dependent, Scattering of a particle by a short-range potential, Scattering by screened Cou-lomb field, Scattering by complex potential.

Integral Equation Formulation: Lippmann-Schwinger integral Equation and its formal solutions, Intergral tepresentation of the scattering amplitude, Convergence of the Gorn Series, Validity of Born approximation, Transition probabilities and cross setions.

Semi-Classical Approximations : WKB approximation, Eikonal approximation.

Variational Principles in the Theory of Collisions: General formulation of the variational principle, Hulthen, Kohn-Hulthen and Sxhwinger variational methods, Determination of Phase shifts, Scattering length and scattering amplitude for central force problems, Bound (minimum) principles.

Analytic Properties of Sxattering Amplitudw : Jost function, Scattering matrix, Bound states and resonances, Levinson theo-rem, Dispersinon relations, Effective range theory.

References :

1. A. Messiah-Quantum Mechanice, Vol. I & II (North Holland Pub. Co., 1962).
2. B. H. Bransden & C. J. Joachain- Introduction to Quantum Mechamicw (Oxford University Press, 1989).
3. P. G. Burke - Potential Scattering in Atomic Physics (Plenum Press, New York,1977)
4. C. J. Joachain - Quantum Collision Theory (North-Holland Pub. Co., 1975)
5. B. H. Bransden - Atomic Collision Theory (W.A. Benjamin Inc., N. Y. 1970)
6. S. Geltman - Topics in Atomic Collision Theory (Academic Press. 1969)
7. T.Y. Wu and T. Olmura - Quantum Theory of Scatterring (Prentice Hall, New Jersey, 1962)
8. N. F. Mott & H. S. W. Massy - Theory of Atomic collisions (3rded.), (Clarendon Press, Oxford, 1965)
9. M. L. Goldberger & K. M. Watson - Collision Theory (Wiley, N. Y. 1964)
10. R. G. Newton - Scattering Theory of Waves and Particles (Mcgraw - Hill, 1966)

B: Advanced Operations Research-II

Dynamic Programming : Characteristics of Dynamic Program-ming problems, Bellman's principle of optimality (Mathematical formulation).

Model -1: Single additive constraint, multiplicative seprable return,

Model -2: Single additive constraint, additively separable return, seprable return,

Model -3: Single a multiplicative Constraint, additively seprable return,

Multistage decision process – Forward and Backward recursive approach, Dynamic

Programming approach for solving linear and non-linear programming problems, Application– Singleitem N-period deterministic inventory model.

Geometric Programming : Elementary properties of Geometric Programming and its applications.

Queuing Theory : Introduction, characteristic of Queuing systems, operating characteristics of Queuing system. Probability distribution in Queuing systems. Classification of Queuing models. Poisson and-non Poisson queuing model.

References :

1. G. Hadly - *Non-Linear and Dynamic Programming*. Addison – Wesley, Reading Mass.
2. S. Dano – *Non-Linear and Dynamic Programming*
3. H. A. Taha – *Operations Research – An Introduction*, Macmillan Publishing Co., Inc., New York.
4. Swarup, Gupta & Manmohan – *Operations Research*, Sultan Chand & Sons New Delhi.
5. N. S. Kambo – *Mathematical Programming Techniques*. Affili-ated East-West Press Pvt. Ltd. New Delhi.

C: Inviscid Compressible Flows and Turbulence-II

Turbulence:

Introduction, Reynold’s equations of mean motion for turbulent flow, Reynold’s stress-tensor; eddy viscosity. Phenomenologi-cal theories. Mixing length Prandtl’s momentum transfer theory, Taylor’s vorticity theory. karman’s similarity hypoth-esis. Velocity distribution in channel flow under constant pres-sure gradient

Spread of turbulence: Mixing zone between two parallel flows, (two-dimensional) turbulent wake behind. (i) symmetrical cylin-der (ii) a row of parallel rods. Turbulent flow through smooth circular pipes; Seventh power velocity distribution low; turbulent boundary layer on a flat plate.

Statistical approach; Introductory concept; double correlation between velocity components, longitudinal and lateral; correlations in homogeneous turbulence; Eulerian correlation with respect to time, Taylor’s one-dimensional energy spectrum. Energy relations in turbulent flows.

References :

1. S. W. Yuam: *Foundations of Fluid Mechanics*, PHI, 1969
2. H. Schlichting: *Boundary Layer Theory*, Mc Graw-Hill Book Comp., 2004
3. L.D. Landau and E. M. Lifshitz: *Fluid Mechanecs*, Pergamon Press, 1959.
4. J.L. Bansal: *Viscous Fluid Dynamics*, 2003.
5. J.A. Shercliff: *A text Book of Magnetohydrodynamics*
6. V. C. A. Ferraro-and C. Plumpton: *An Introduction to magneto fluid Mechanics*, Oxford Univ, Press, 1961.

D: Computational Fluid Dynamics-II

Multigrid method, Conjugate – Gradient method. Incompressible Navier – Stokes (NS) equations – Boundary conditions, Spatial and temporal discretization on collocated and on staggered grids. Development of the MAC Method for NS equations, Implementation of boundary conditions.

Grid Generation by Algebraic mapping : One-dimensional stretching functions, Boundary – Filtered Coordinate Systems : Elliptic Grid generation. Solution of Euler Equations in General Co-ordinates. Numerical Solution of NS Equations in General Co-ordinates.

References :

1. Peter Linz – Theoretical Numerical Analysis, An Introduction To Advanced Technique (John Wiley & Sons.)
2. R. Peyret and T. D. Taylor – Computational Methods for fluid Flow (Springer – Verlag)
3. P. Wesseling – Principles of Computational Fluid Dynamics (Springer-Verlag, 2000)
4. J. D. Anderson – Computational Fluid Dynamics : The Basics With Applications (McGraw-Hill, 1998)
5. C. A. J. Fletcher – Computational Techniques for Fluid Dynamics. Vol. I and II (Springer-Verlag).
6. Dale A. Anderson, John C. Tannehill, Richard H. Pletcher – Computational Fluid mechanics and Heat Transfer (Hemisphere publishing Corporation)

Paper – MAT 405

Term Paper

Marks : 50

FOR REGULAR STUDENTS

Term Paper MAT 405 is related with the special papers of the applied stream offered by the department in each session and the topic of the term paper will also be decided by the department in each session. However the mark distribution is 30 marks for written submission, 15 marks for seminar presentation and 5 marks for viva-voice.

FOR DDE STUDENTS

Instead of Term Paper for the regular students of a paper of 50 Marks, a comprehension test will be held. It will be based on his special papers from which 5 questions may be set and the candidates will be required to answer 3 of them and in answering these the candidates may take help from any book or study materials within the examination hall but not from the outside, that is for this paper, it is an open book examination system.

SEMESTER IV
PURE MATHEMATICS STREAM
Paper - MPG 401
(Modern Algebra- III) (Marks -50)

Field Theory : Extension of fields, Simple extensions, Algebraic and Transcendental extensions, Splitting fields, Algebraically closed fields, normal extension, separable extensions, Perfect field.

Automorphism of fields, Galois field, Galois extension, Fundamental Theorem of Galois theory, primitive elements, Solution of polynomial equations by radicals, Insolvability of the general equation of degree five or more by radicals, Cyclotomic extensions, Ordered field, Valuation, Completion.

Modules : Artinian and Noetherian Modules, Fundamental Structure Theorem for finitely generated modules over a P.I.D and its application to finitely generated Abelian groups.

References :

1. S. Lang - *Algebra* (P.H.I)
2. Hungerford - *Algebra*.
3. D.S. Malik, J. N. Mordeson & M. K. Sen - *Fundamentals of Abstract Algebra* (McGraw- Hill)
4. I. T. Adamson - *Introduction to Field Theory* -(Cambridge University Press)
5. S. Lang - *Algebra*
6. M. M. Postnikov - *Fundamentals of Galois' Theory*.
7. Dummit & Foote - *Abstract Algebra*.

Paper – MPG 402
(General Topology - II & Functional Analysis - II)
Group – A
General Topology - II (Marks – 30)

Connectedness and characterization of connected subsets, union of connected subsets. Connected subsets of the real line. local connectedness, components, structure of open sets in locally connected second countable spaces. connectedness of the product spaces One-point Compactification, Stone - Eech compactification (Without proof)
Compactness in metric spaces, Properties of Compact metric spaces
Urysohn's metrization theorem, Uniform structure, uniform topology, uniform spaces, uniform continuity, Cauchy filter, total boundedness, completeness and compactness.
Homotopy of paths, covering spaces, fundamental group. Definition of the fundamental group of the circle.

References :

1. J. Dugundji – Topology (Allayn and Bacon, 1966)
2. J. L. Kelley – General Topology (Van Nostrand, 1955)
3. J. R. Munkres – Topology – A First Course (Prentice-Hall of India, 1978)
4. G. F. Simmons – Introduction to Topology and Modern, Analysis (Mcgraw - Hill, 1963)
5. W. J. Thron – Topological Structures (Holt Reinhurt and Winston, 1966)
6. B. K. Lahiri - Algebraic topology, Narosa puglishing House Pvt. Ltd. New Delhi

Group – B

Functional Analysis - II (Marks – 20)

Invertible Mappings and their properties. Linear functionals. Hahn-Banach theorem and its applications. Conjugate spaces, Reflexive spaces

Properties of strong and weak convergence. Adjoint (Conjugate) operators and their properties. Hilbert Spaces, $L_p [a,b]$ ($1 \leq p \leq \infty$)

Continuity of inner product. Convergence, Orthogonality and orthogonal decomposition of a Hilbert Space, Orthogonal set. Bessel's inequality. Parseval's identity. Minimization of norm problem. Complete orthonormal set. Riesz-Fischer theorem. Riesz representation theorem for bounded linear functionals on Hilbert spaces.

References :

1. Lusternik and Sovolev-*Functional Analysis*
2. A. H. Siddiqui- *Functional Analysis with applications*, TMG Publishing Co. Ltd, New Delhi
3. K. K. Jha – *Functional Analysis, Student's Friends*, 1986
4. Vulikh - *Functional Analysis*
5. G. Bachman & L. Narici - *Functional Analysis, Academic press*, 1966
6. A. E. Taylor - *Functional Analysis, John wiley and Sons, New York*, 1956
7. E. Kreyszig-*Introductory Functional Analysis with Applications*, Wiley Eastern, 1986
8. L. V. Kantorovich and G.P. Akilov-*Functional Analysis*, Pergamon Press, 1982
9. B.K. Lahiri-*Elements of Functional Analysis*, The world Press Pvt. Ltd, Kolkata, 1994
10. G. F. Simmons-*Introduction to Topology and Modern Analysis* Mc Graw Hill, New York, 1963

11. B. V. Limaye-*Functional Analysis*, Wiley Eastern Ltd.

Paper – MPS 403
(Special Paper -III) (Marks – 50)
A: Differential Geometry of Manifolds-II

Riemannian manifolds. Riemannian connection. Curvature tensors. Sectional Curvature. Schur's theorem. Geodesic in a Riemannian manifold. Projective curvature tensor. Conformal curvature tensor.

Submanifolds and Hypersurfaces. Normals. Gauss' formulae. Weingarten equations. Lines of curvature. Generalized Gauss and Mainardi-Codazzi equations.

Almost Complex manifolds. Nijenhuis tensor. Contravariant and covariant almost analysis vector fields. F-connection.

References :

1. R. S. Mishra, *A course in tensors with applications to Riemannian Geometry*, Pothishala (Pvt.) Ltd., 1965.
2. R. S. Mishra, *Structures on a differentiable manifold and their applications*, Chandrama Prakashan, Allahabad, 1984.
3. B. B. Sinha, *An Introduction to Modern Differential Geometry*, Kalyani Publishers, New Delhi, 1982
4. K. Yano and M. Kon, *Structure of Manifolds*, World Scientific Publishing Co. Pvt. Ltd., 1984.
5. U. C. De and A. A. Shaikh, *Differential Geometry of Manifolds*, Narosa Publishing House Pvt. Ltd., 2007.

B: Advanced Real Analysis - II

Density of arbitrary linear sets. Lebesgue Density theorem. Approximate continuity. Properties of approximately continuous functions. Bounded approximately continuous function over $[a, b]$ and exact derivative.

The Perron integral : Definitions and basic properties, Comparison with Lebesgue integral and Newton integral.

Trigonometric system and trigonometric Fourier series. Summability of Fourier series by (C, I), means. Fejer's theorem.

Lebesgue's theorem Completeness of Trigonometric system.

Sets of first and of the second Categories. Baire's theorem for G_δ residual and perfect sets points of condensation of a set.

Baire classification of functions, Functions of Baire class one. Baire's theorem. Semicontinuous functions.

References:

1. Hewitt and Stormberg - *Real and Abstract Analysis*

2. H. L Royden - *Real analysis*
3. Saks- *Theory of Integrals*
4. W. Rudin - *Real and Abstract Analysis*
5. M. E.s Munroe - *Measure and Integration*
6. I. P. Natanson - *Theory of Function of a Real Variable*, Vols. I & II.
7. E.W. Hobson - *Theory of Functions of a Real Variable*, Vols. I & II

C: Advanced Functional of a Analysis - II

Stone- Weierstrass W-capital theorem in $C(X, \mathbb{R})$ and $C(X, \mathbb{C})$ where X is a compact Hausdorff space, Representation theorem for bounded linear functionals on $C[a, b]$, $L_p[a, b]$, $(1 \leq p < \infty)$ and $L_p[a, b]$, $(1 \leq p < \infty)$ consequences of uniform boundedness principle, weak topology, weak topology, Banach-Alaoglu theorem.

Approximation Theory in Normed Linear space, Best approximation, Uniqueness Criterion, Separable Hilbert Space.

Banach Algebra, Identity element, analytic property of resolvent Operator, Compactness of Spectrum, Spectral radius and Spectral mapping Theorem for polynomials, Gelfand Theory on representation of Banach Algebra, Gelfand Neumark Theorem.

References :

1. W. Rudin-Functional Analysis, TMG Publishing Co. Ltd. New Delhi, 1973
2. A. A. Schaffer-Topological vector spaces, Springer, 2nd Edn., 1991
3. G. Bachman & L. Narici- Functional Analysis, Academic Press, 1966
4. E. Kreyszig-Introductory Functional Analysis with Applications, Wiley Eastern, 1989
5. Diestel Application of Geometry of Banach Spaces
6. Narici & Beckerstein Topological Vector spaces, Marcel Dekker Inc, New York and Basel, 1985
7. G. F. Simmons Introduction to topology and Modern Analysis Mc Graw Hill, New York, 1963
8. A. F. Taylor- Functional Analysis, John Wiley and Sons, New York, 1958
9. Lipschitz-General Topology, Schaum Series
10. K. Yosida-Functional Analysis Springer Verlag, New York. 3rd Edn. 1990
11. Brown. and Page-Elements of Functional Analysis, Von Nostrand Reinhold Co. 1970
12. Holmes-Geometric Functional Analysis and its Application
13. J. Horvath-Topological Vector spaces and Distributions, Addison-Wesley Publishing Co. 1966
14. C. Goffman and G. Pedrick-Frist Course in Functional Analysis, PHI, New Delhi, 1987

15. R. E. Edwards- Functional Analysis, Holt Reinhart and Wilson, New York, 1965
16. A. Wilansky-Functional Analysis, TMG Publishing Co. Ltd. New Delhi, 1973

D: Rings of Continuous Function-II

Partially ordered rings, convex ideals, absolutely convex ideals, properties of convex ideals, lattice ordered rings, total orderedness of the residue class rings modulo prime ideals in $C(X)$ and $C(X)$ real ideals, hyper-real ideals in $C(X)$. Limit ordinal, non-limit ordinals compactness of the spaces of the Ordinals, first uncountable ordinals space and its “one point compactification” and relation between the rings of continuous function on them, Characterization of real ideals.

Cluster point and convergence of Z -filters on a dense subset of a Tychonoff space. Characterization of C^* - embedded dense subset of a Tychonoff space. Construction of Stone-Eech compactification. More specific properties of $\beta\mathbb{N}$ and $\beta\mathbb{Q}$ and $\beta\mathbb{R}$.

Characterization of maximal ideals in $C^*(X)$ and $C(X)$. Gelfand-Kolmogorov theorem. Structure space of a commutative ring another description of βX . The Banach-Stone theorem. Partial ordered set $K(X)$ of the T_2 Compactifications of a Partial ordered set X , elements of $K(X)$ and the subsets of $C^*(X)$. Local compactness and the complete lattice $K(X)$.

References :

1. Richard E. Chandler, *Hausdorff Compactifications* (Marcel Dekker, Inc. 1976).
2. L. Gillman and M. Jerison, *Rings of Continuous Functions* (Von Nostrand, 1960).
3. *Topological Structures* (Halt Reinhart and Winston, 1966).

E : Theory of Rings And Algebras-II

Other Radicals and Radical Properties : The Levitzki Radical, Brown-Mcloy radicals, Amitsur’s properties, Relations among the radicals.

Generalizations of the notions of radicals to other systems: Algebras, Group Algebras, Near rings, Groups, Lattices. Lie & Jordan Algebras : Definitions, Nilpotency and Solvability, A structure theorem for nonassociative algebras, Jordan Algebras, Lie Algebras, Simple Lie and Jordan algebras.

Category Theory : Definition, Functions, Objects and morphisms, Kernels and images, Exact Categories, Products & limits, abelian Categories.

Radical subcategories, Applications of sheaf theory to the study of rings.

Elements of Universal Algebra.

References :

1. Mary Gray—*A Radical Approach to Algebra* (Addison-Wesley Publishing Company).
2. Ernst – August Behrens (Translated by Clive Reis) – *Ring Theory* (Academic Press, New York, London).
3. Stanley Burris & H. P. Sankappanvar—*A Course in Universal Algebra* (Springer-Verlag, New York, Berlin)
4. L. H. Rowen – *Ring Theory* (Academic Press)

5. T. Y. Lam – *Nocommutative Rings* (Springer-Verlag)
6. N. Jacobson – *Basic Algebra – II*.
7. N. Herstein – *Noncommutative Rings*
8. N. J. Divisky – *Rings and Radicals*
9. N. H. McCoy – *The Theory of Rings*
10. M. R. Adhikari – *Groups, Rings, Modules and applications.*

F. Non Linear Optimization In Banach Spaces-II

Tangent Cones-Definition and properties. Optimality Conditions. Lyusternik theorem. Generalized Lagrange Multiplier Rule– Problem formulation. Necessary and Sufficient optimality conditions. Application to optimal control problems. Duality-Problem formulation. Duality theorem Saddle point theorems. Linear problems. Application to approximation problems. Some special optimization problems-Linear quadratic optimal control problems. Time optimal control problems.

References :

1. Johannes John – *Introduction to the Theory of Nonlinear Optimization* (Springer-Verlag, 1994)
2. V. Bartu and T. Precupanu – *Convexity and Optimization in Banach Spaces* (Editura Acad. Bucuresti, 1986).
3. A. V Balakrishnan – *Applied Functional Analysis* (Springer-Verlag)

G: Harmonic Analysis - II

Hardy spaces on the unit circle. Invariant subspaces. Factoring. Proof of the F. and M. Riesz theorem. Theorems of Beurling and Szegő in multiplication operator form. Structure of inner and outer functions.

The Inequalities of Hardy and Hilbert. Conjugate functions. Theorems of Kolmogorov & Zygmund and M. Riesz & Zygmund on conjugate functions.

The conjugate function as a singular integral. Statement of the Burkholder-Gundy Silverstein Theorem on. T. Maximal functions of Hardy and Littlewood Translation. The Theorems of Wiener and Beurling. The Titchmarsh Convolution Theorem. Wiener's Tauberian Theorem. Spectral sets of bounded functions.

References :

1. Henry Helson - *Harmonic Analysis* (Hindustan Pub. Corp 1994)
2. E. Hewitt and K. A. Ross – *Abstract Harmonic Analysis Vol. I* (Springer-Verlag, 1993)
3. Y. Katznelson – *An Introduction to Harmonic Analysis* (John Wiley, 1968)
4. P. Koosis – *Introduction of Hp Spaces* (Cambridge Univ Press).
5. R. R. Goldberg – *Fourier transforms*
6. T. Huisain, – *Introduction to topological groups*

H : Applied Functional Analysis -II

Semigroups of linear operators-general properties of semigroups. Generation of semigroups. Dissipative semigroups Compact semigroups.

Holomorphic semigroups, Elementary examples of semigroups, Extension. Differential Equations. Cauchy Problem, Controllability. State reduction. Observability. Stability and Stabilizability Evolution equations.

Optimal Control Theory-Linear quadratic regulator problem. The same problem with infinite time interval. Hard constraints Final value control. Time optimal control problems.

References :

1. A. V. Balakrishnan—*Applied Functional Analysis*, Springer-Verlag.
2. Dunford and Schwartz—*Linear operators*, vol 1 & 11.
3. S. G. Krein—*Linear Differential Equations in a Banach space*.
4. K. Yosida—*Functional Analysis*.

Paper – MPS404

(Special Paper -IV) (Marks –50)

A: Measure and Integration - II

Signed measures, Hahn-decomposition theorem. Jordan decomposition theorem. Radon-Nikodym theorem. Radon-Nikodym derivative. Lebesgue decomposition theorem. Complex measure. Integrability of functions w.r.t. signed measure and complex measure. Measurable Rectangles, Elementary sets, Product measures. Fubini's theorem.

L_p [a,b] – spaces ($1 \leq p \leq \infty$). Holder and Minkowski inequality. Completeness and other properties of L_p [a, b] spaces. Dense subspaces of L_p [a,b]– spaces. Bounded linear functionals on

L_p [a,b] – spaces and their representations.

References :

1. I. P. Rana – Measure and Integration
2. G. D. Barra – Measure and Integration
3. Hewitt and Stormberg—Real and Abstract Analysis
4. H. L. Royden – Real Analysis
5. W. Rudin – Real and Abstract Analysis
6. M. E. Munroe – Measure and Integration
7. Taylor – Measure and Integration
8. I. P. Natanson – Theory of Functions of a Real Variable. Vols. I & II.
9. Charles Schwartz—Measure. Integration and Functions Spaces. World Scientific Publi., 1994.

B: Operator Theory And Applications-II

Spectral properties of bounded - Linear operators in normed linear space; Spectrum, regular value, resolvent of operator; closure property and boundedness property of spectrum, spectral radius.

Eigenvalues, eigen-vectors of self-adjoint operators in Hilbert space. Resolvent sets, real property of spectrum of self-adjoint operators, range of spectrum, Orthogonal direct sum of Hilbert space,

Spectral-theorem for compact normal operators, Sesquilinear functionals, property of boundedness and symmetry, Generalisation of Cauchy-Schwarz inequality.

Unbounded-operators and their adjoint in Hilbert spaces.

References:

1. G. Bachman & L. Narici-Functional Analysis, Academic Press, 1966
2. B.V. Limaye-Functional Analysis, Wiley Eastern Ltd
3. E. Dreyzig-Introductory Functional Analysis with Applications, Wiley Eastern, 1989
4. B.K. Lahiri-Elements of Functional Analysis, The world Press Pvt. Ltd. Kolkata, 1994
5. G. F. Simmons-Introduction to topology and Modern Analysis Mc Graw Hill, New York, 1963
6. N. Dunford and J. T. Schwartz-Linear Operators, Vol-I&II, Interscience, New York, 1958
7. K. Yosida-Functional Analysis, Springer Verlag, New York, 3rd Edn., 1990
8. Brown and Page-Elements of Functional Analysis, Von Nostrand Reinhold Co., 1970
9. A.E. Taylor- Functional Analysis, John Wiley and Sons, New York, 1958
10. L.V. Kantorovich and G.p. akilov-Functional Analysis, Pergamon Press, 1982
11. Vulikh- Functional Analysis
12. J. Tinsley Oden & Leszek F. Dernkowicz-Functional Analysis, CRC Press Inc, 1996
13. Lipschitz-General Topology, Schaum Series

C: Algebraic Topology -II

Introduction of singular homology and cohomology group by Eilenberg and Steenrod axioms. Existence and Uniqueness of singular homology and cohomology theory.

Calculation of homology and cohomology groups for circle. Projective spaces torus relation between $H_1(X)$ and $\pi_1(X)$.

Singular cohomology ring, calculation of cohomology ring for projective spaces. Fibre bundles : Definitions and examples of bundles and vector bundles and their morphisms, cross sections, fibre products, induced bundles and vector bundles and their morphisms, cross sections, fibre products, induced bundles and vector bundles, homotopy properties of vector bundles. Homology exact sequence of a fibre bundle.

References :

1. W.S. Massey – Algebraic Topology
2. W.S. Massey – Singular Homology Theory
3. E. H. Spanier – Algebraic Topology
4. B. Gray – Homotopy Theory An Introduction to Algebraic Topology
5. C. R. Bredon – Geometry and Topology

D: Lattice Theory - II

Covering condition in modular lattices of locally finite length, Complemented modular lattices, Boolean algebras, complete Boolean algebras, Boolean algebras and Boolean rings, valuation of a lattice, metric and quasimetric lattice.

Complete Lattice, conditionally complete Lattices, Fix point theorem, Compactly generated lattices, subalgebra lattices. Birkhoff lattices, Semimodular lattices, Complemented semimodular lattices, Ideal chains, Ideal Lattices, Distributive lattices and ring of sets, Congruence relations, Ideals and congruence relations.

References :

1. G. Szasz – Lattice Theory
2. G. Birkhoff – Lattice Theory
3. B. H. Arnold – Logic and Boolean Algebra
4. D. E. Rutherford – Lattice Theory

E: Advanced Operations Research-II

Dynamic Programming : Characteristics of Dynamic Programming problems, Bellman's principle of optimality (Mathematical formulation)

Model –1 : Single additive constraint, multiplicative separable return,

Model –2 : Single additive constraint, additively separable return,

Model –3 : Single multiplicative constraint, additively separable return,

Multistage decision process – Forward and Backward recursive approach, Dynamic Programming approach for solving linear and non-linear programming problems, Application – Singleitem N-period deterministic inventory model.

Geometric Programming : Elementary properties of Geometric Programming and its applications.

Queuing theory : Introduction, characteristic of Queuing systems, operating characteristics of Queuing system. Probability distribution in Queuing systems. Classification of Queuing models. Poisson and non-Poisson queuing models.

References :

1. G. Hadly - *Non-Linear and Dynamic Programming*, Addison - Wesley, Reading Mass.
2. S. Dano - *Non-Linear and Dynamic Programming*

3. H. A. Taha - *Operations Research - An Introduction*, Macmillan Publishing Co., Inc., New York..
4. Swarup Gupta & Manmohan - *Operations Research*, Sultan Chand & Sons, New Delhi.
5. N.S. Kambo- *Mathematical Programming Techniques*, Affiliated East-West Press Pvt. Ltd., New Delhi.

F: Geometric Functional Analysis-II

Extreme points. Convex functions and optimization. Some More Applications: The category Theorems.

The Smulian Theorems. The theorem of James. Support Points and smooth points. Some further Application. Isomorphism of certain conjugate space. Universal spaces.

References :

1. Holmes - *Geometric Functional Analysis and Its Applications*.

G : Proximities, Nearnesses and Extensions of Topology Spaces-II

Separated proximities, separation axioms satisfied by the closure operators induced by RI - (LO -, EF-) proximities. The Lattice structure of the class of RI - (LO-, EF-) proximities compatible with a suitable closure operator. (Basic) nearness, near families, contiguities, contigal families, closure operators, proximities and contiguities induced by a (basic) nearnesses, merotopic spaces. Nearness preserving maps. Separated nearnesses, merotopic spaces. Nearness preserving maps. Separated nearnesses. The class of basic nearnesses compatible with a symmetric closure space (a proximity space, a contiguity space) and their Lattice structure.

Clans, clusters and cluster generated (concrete) nearnesses. Nearnesses are not clan generated structures. Classification of basic nearness : Riesz (RI -) nearnesses, Lodato (LO -) nearnesses and Efremovie (EF -) nearnesses, their characterization and relationship between them. Nearness spaces, cluster generated nearness spaces, contigal nearness spaces and proximal nearness spaces and relation between them.

Correspondence between the principle (strict) T_1 extensions of a T_1 topological space X and the cluster generated compatible LO - nearnesses on X ; the correspondence between principal T_1 compactification of X and the compatible contigal LO - nearnesses on X ; the correspondence between the principal T_1 linkage compactifications of X and the compatible proximal Lo - nearnesses on X . The correspondence between EF - nearnesses on a Tychonoff space X and the T_2 compactifications of X .

References :

1. S. A. Naimpully and B. D. Wanack - *Proximity Spaces* (Cambridge Track No. 59, Cambridge, 1970)
2. W. J. Thron - *Topological Structures* (Halt Reinhurt and Winster, 1966)
3. E. Eech - *Topological Structures* (English Transl Wiley, New York, 1966)

H: Advanced Complex Analysis-II

Spaces of continuous functions, Ascoli-Arzela theorem, Spaces of Analytic functions, Hurwitz's theorem, Riemann mapping theorem.

Meromorphic function, Mittag-letter's theorem.

Elliptic function, weistrass's elliptic function $p(z)$, addition theorem for $p(z)$, differentisl equation satisfied by $p(z)$, the numbers e_1, e_2, e_3 -

References :

1. J. B. Conway – Functions of One Complex Variable
2. L. V. Ahlfors – Complex Analysis
3. W. Rudin – Real and Complex Analysis
4. E. C. Trichmarsh – Theory of Funtions
5. E. t. Coposon – Function of Complex Variable
6. R. P. Boas – Entire Funtions
7. H. Catarn – Entire Funtions
8. A. I. Markusevich – Theory of Funtions
able, Vol. I & II.
9. M. Dutta and Lokenath Debnath – Elliptic Functions.

Paper – MPT405

Term Paper

Marks : 50

FOR REGULER STUDENTS

Term Paper MPT405 related with the speacial papers of the pure stream offered by the department in each seession and the topic of the term paper will also be decided by the department in each session. However the mark distribution in 30 marks for written submission, 15 marks for seminar presentation and 5 marks for viva-voice.

FOR DDE STUDENTS

Instead of Term Paper for the regular students of a paper of 50 marks, a comprehension test will be held . It be based on his special papers from which 5 questions may be set and the candidates will be required to answer 3 of them and in answering these the the candidates may take help from any book or study materials within the examination hall but not from the outside, that is for this paper , it is an open book examination system.