

**Scheme of Examination-Semester System
For
M.Sc. Mathematics(Semester-III & IV)
(w.e.f. Session 2014-15)**

SEMESTER-III

Paper Code	Title of the Paper	Theor y Marks	Internal- Assessment Marks	Practicals Marks	Total Marks
12MM 511	Functional Analysis-I	80	20	-	100
12MM 512	Partial Differential Equations and Mechanics	80	20	-	100
12MM 513	Complex Analysis-I	80	20	-	100
12MM 514	One paper out of either Group A ₁ or Group B ₁	80	20	-	100
12MM 515	One paper out of either Group C ₁ or Group D ₁	80	20	-	100
Total Marks Semester-III					500
Total Marks Semester-II					500
Total Marks Semester-I					500
GRAND TOTAL					1500

Group A₁

- A₁₁ Advanced Functional Analysis-I
- A₁₂ Advanced Discrete Mathematics-I
- A₁₃ Algebraic Coding Theory-I

- A₁₄ Wavelets-I
- A₁₅ Sobolev Spaces-I
- A₁₆ Frames and Riesz Bases-I

Group B₁

- B₁₁ Mechanics of Solids-I
- B₁₂ Continuum Mechanics-I
- B₁₃ Computational Fluid Dynamics-I
- B₁₄ Difference Equations-I
- B₁₅ Information Theory-I

Group C₁ (Pre-requisite : Group A₁)

- C₁₁ Theory of Linear Operators-I
- C₁₂ Analytical Number Theory-I
- C₁₃ Fuzzy Sets and Applications-I
- C₁₄ Bases in Banach Spaces-I
- C₁₅ Algebraic Topology-I

Group D₁ (Pre-requisite : Group B₁)

- D₁₁ Fluid Dynamics-I
- D₁₂ Bio-Mechanics-I
- D₁₃ Integral Equations and Boundary Value Problems-I
- D₁₄ Mathematics of Finance and Insurance-I
- D₁₅ Space Dynamics-I

Note 1: The marks of internal assessment of each paper shall be split as under :

- A) One class test of 10 marks. The class test will be held in the middle of the semester.
- B) Assignment & Presentation : 5 marks
- C) Attendance : 5 marks
 - 65% but upto 75% : 1 marks
 - More than 75% but upto 85% : 2 marks
 - More than 85% but upto 90% : 3 marks
 - More than 90% but upto 95% : 4 marks
 - Above 95% : 5 marks

Note 2: The syllabus of each paper will be divided into **four** units of **two** questions each. The question paper will consist of **five** units. Each of the first four units will contain two questions and the students shall be asked to attempt **one** question from each unit. Unit five of each question paper shall contain **eight to ten** short answer type questions without any internal choice and it shall be covering the entire syllabus. As such unit five shall be **compulsory**.

Note 3: As per UGC Recommendations, the teaching program shall be supplemented by tutorials and problem solving sessions for each theory paper. For this purpose, tutorial classes shall be held for each theory paper in groups of 8 students for half-hour per week.

Note 4: Optional papers can be offered subject to availability of requisite resources/ faculty.

Syllabus- 3rd SEMESTER

12MM 511 : Functional Analysis-I

Max. Marks : 80

Time : 3 Hours

Unit -I (2 Questions)

Normed linear spaces, Metric on normed linear spaces, Completion of a normed space, Banach spaces, subspace of a Banach space, Holder's and Minkowski's inequality, Completeness of quotient spaces of normed linear spaces. Completeness of l_p , L^p , R^n , C^n and $C[a,b]$. Incomplete normed spaces.

Unit -II (2 Questions)

Finite dimensional normed linear spaces and Subspaces, Bounded linear transformation, Equivalent formulation of continuity, Spaces of bounded linear transformations, Continuous linear functional, Conjugate spaces, Hahn-Banach extension theorem (Real and Complex form).

Unit -III (2 Questions)

Riesz Representation theorem for bounded linear functionals on L^p and $C[a,b]$. Second conjugate spaces, Reflexive space, Uniform boundedness principle and its consequences, Open mapping theorem and its application projections, Closed Graph theorem.

Unit -IV (2 Questions)

Equivalent norms, Weak and Strong convergence, their equivalence in finite dimensional spaces. Weak sequential compactness, Solvability of linear equations in Banach spaces.

Compact operator and its relation with continuous operator. Compactness of linear transformation on a finite dimensional space, properties of compact

operators, compactness of the limit of the sequence of compact operators, the closed range theorem.

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

Books Recommended

1. H.L. Royden, Real Analysis, MacMillan Publishing Co., Inc., New York, 4th Edition, 1993.
2. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley.
3. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.
4. A. H. Siddiqi, Khalil Ahmad and P. Manchanda, Introduction to Functional Analysis with Applications.

12MM 512 : Partial Differential Equations and Mechanics

Max. Marks : 80

Time : 3 Hours

Unit – I(2 Questions)

Method of separation of variables to solve B.V.P. associated with one dimensional heat equation. Solution of two dimensional heat equation and two dimensional Laplace equation. Steady state temperature in a rectangular plate, in the circular disc, in a semi-infinite plate. The head equation in semi-infinite and infinite regions. Temperature distribution in square plate and infinite cylinder. Solution of three dimensional Laplace equation in Cartesian, cylindrical and spherical coordinates. Dirichlets problem for a solid sphere. (Relevant topics from the books by O'Neil)

Unit -II(2 Questions)

Method of separation of variables to solve B.V.P. associated with motion of a vibrating string. Solution of wave equation for Semi-infinite and infinite strings. Solution of wave equation in two dimensions. Solution of three dimensional wave equation in Cartesian, cylindrical and spherical coordinates. Laplace transform solution of B.V.P.. Fourier transform solution of B.V.P. (Relevant topics from the books by O'Neil)

Unit-III(2 Questions)

Kinematics of a rigid body rotating about a fixed point, Euler's theorem, general rigid body motion as a screw motion, moving coordinate system - rectilinear moving frame, rotating frame of reference, rotating earth. Two-dimensional rigid body dynamics – problems illustrating the laws of motion and impulsive motion. (Relevant topics from the book of Chorlton).

Unit -IV(2 Questions)

Moments and products of inertia, angular momentum of a rigid body, principal axes and principal moment of inertia of a rigid body, kinetic energy of a rigid body rotating about a fixed point, momental ellipsoid and equimomental systems, coplanar mass distributions, general motion of a rigid body. (Relevant topics from the book of Chorlton).

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

Books Recommended

1. Sneddon, I.N. Elements of Partial Differential Equations, McGraw Hill, New York.
2. O'Neil, Peter V. Advanced Engineering Mathematics, ITP.
3. F. Chorlton Textbook of Dynamics, CBS Publishers,

- New Delhi.
4. H.F. Weinberger A First Course in Partial Differential Equations, John Wiley & Sons, 1965.
 5. M.D. Raisinghania Advanced Differential equations, S. Chand & Co.

12MM 513 : Complex Analysis-I

Max. Marks : 80

Time : 3 hours

Unit -I(2 Questions)

Function of a complex variable, continuity, differentiability. Analytic functions and their properties, Cauchy-Riemann equations in Cartesian and polar coordinates. Power series, Radius of convergence, Differentiability of sum function of a power series. Branches of many valued functions with special reference to $\arg z$, $\log z$ and z^a .

Unit -II(2 Questions)

Path in a region, Contour, Simply and multiply connected regions, Complex integration. Cauchy theorem. Cauchy's integral formula. Poisson's integral formula. Higher order derivatives. Complex integral as a function of its upper limit, Morera's theorem. Cauchy's inequality. Liouville's theorem. The fundamental theorem of algebra. Taylor's theorem.

Unit -III(2 Questions)

Zeros of an analytic function, Laurent's series. Isolated singularities. Cassorati- Weierstrass theorem, Limit point of zeros and poles.

Maximum modulus principle, Minimum modulus principle. Schwarz lemma. Meromorphic functions. The argument principle. Rouché's theorem, Inverse function theorem.

Unit - IV(2 Questions)

Calculus of residues. Cauchy's residue theorem. Evaluation of integrals.

Bilinear transformations, their properties and classifications. Definitions and examples of Conformal mappings.

Space of analytic functions and their completeness, Hurwitz's theorem. Montel's theorem. Riemann mapping theorem.

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

Books Recommended

1. H.A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
2. J.B. Conway, Functions of one Complex variable, Springer-Verlag, International student-Edition, Narosa Publishing House, 1980.
3. Liang-shin Hann & Bernard Epstein, Classical Complex Analysis, Jones and Bartlett Publishers International, London, 1996.
4. E.T. Copson, An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, London.
5. E.C. Titchmarsh, The Theory of Functions, Oxford University Press, London.
6. L.V. Ahlfors, Complex Analysis, McGraw Hill, 1979.
7. S. Lang, Complex Analysis, Addison Wesley, 1977.
8. Mark J. Ablowitz and A.S. Fokas, Complex Variables : Introduction and Applications, Cambridge University Press, South Asian Edition, 1998.
8. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 1997.
9. Ruel V. Churchill and James Ward Brown, Complex Variables and Applications, McGraw-Hill Publishing Company.

12MM 514 (Option A₁₂) Advanced Discrete Mathematics –I

Max. Marks : 80

Time : 3 Hours

Unit - I(2 Questions)

Graph Theory – Definitions and basic concepts, special graphs, Sub graphs, isomorphism of graphs, Walks, Paths and Circuits, Eulerian Paths and Circuits, Hamiltonian Circuits, matrix representation of graphs, Planar graphs, Colouring of Graph.

Unit -II (2 Questions)

Directed Graphs, Trees, Isomorphism of Trees, Representation of Algebraic Expressions by Binary Trees, Spanning Tree of a Graph, Shortest Path Problem, Minimal spanning Trees, Cut Sets, Tree Searching..

Unit -III (2 Questions)

Introductory Computability Theory - Finite state machines and their transition table diagrams, equivalence of finite state machines, reduced machines, homomorphism, finite automata acceptors, non-deterministic finite automata and equivalence of its power to that of deterministic finite automata Moore and Mealy machines.

Unit -IV (2 Questions)

Grammars and Languages – Phrase-structure grammar rewriting rules, derivations, sentential forms, Language generated by a grammar, regular, context-free and context sensitive grammars and languages, regular sets, regular expressions and pumping lemma, Kleene's theorem.

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

Books Recommended

1. J.P. Tremblay & R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Co., 1997.
2. J.L. Gersting, Mathematical Structures for Computer Science, (3rd edition), Computer Science Press, New York.
3. Seymour Lipschutz, Finite Mathematics (International edition 1983), McGraw-Hill Book Company, New York.
4. C.L. Liu, Elements of Discrete Mathematics, McGraw-Hill Book Co.
5. Babu Ram, Discrete Mathematics, Vinayak Publishers and Distributors, Delhi, 2004.

12MM 514 (Option A₁₃) : Algebraic Coding Theory-I

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

The communication channel. The Coding Problem. Types of Codes. Block Codes. Error-Detecting and Error-Correcting Codes. Linear Codes. Hamming Metric. Description of Linear Block Codes by Matrices. Dual Codes.

Unit -II (2 Questions)

Hamming Codes, Golay Codes, perfect and quasi-perfect codes. Modular Representation. Error-Correction Capabilities of Linear Codes. Tree Codes. . Description of Linear Tree

Unit -III (2 Questions)

Bounds on Minimum Distance for Block Codes. Plotkin Bound. Hamming Sphere Packing Bound. Varshamov-Gilbert – Sacks Bound. Bounds for Burst-Error Detecting and Correcting Codes.

Unit -IV (2 Questions)

Convolutional Codes and Convolutional Codes by Matrices. Standard Array. Bounds on minimum distance for Convolutional Codes. V.G.S. bound. Bounds for Burst-Error Detecting and Correcting Convolutional Codes. The Lee metric, packing bound for Hamming code w.r.t. Lee metric.

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

Books Recommended

1. Ryamond Hill, A First Course in Coding Theory, Oxford University Press, 1986.
2. Man Young Rhee, Error Correcting Coding Theory, McGraw Hill Inc., 1989.
3. W.W. Peterson and E.J. Weldon, Jr., Error-Correcting Codes. M.I.T. Press, Cambridge Massachuetts, 1972.
4. E.R. Berlekamp, Algebraic Coding Theory, McGraw Hill Inc., 1968.
5. F.J. Macwilliams and N.J.A. Sloane, Theory of Error Correcting Codes, North-Holand Publishing Company.
6. J.H. Van Lint, Introduction to Coding Theory, Graduate Texts in Mathematics, 86, Springer, 1998.

7. L.R. Vermani, Elements of Algebraic Coding Theory, Chapman and Hall, 1996.

12MM 514 (Option A₁₄) : Wavelets –I

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Definition and Examples of Linear Spaces, Bases and Frames, Normed Spaces, The L^p - Spaces, Definition and Examples of Inner Product Spaces, Hilbert Spaces, Orthogonal and Orthonormal Systems.

Unit - II (2 Questions)

Trigonometric Systems, Trigonometric Fourier Series, Convergence of Fourier Series, Generalized Fourier Series.

Fourier Transforms in $L^1(\mathbb{R})$ and $L^2(\mathbb{R})$, Basic Properties of Fourier Transforms, Convolution, Plancherel Formula, Poisson Summation Formula, Sampling Theorem and Gibbs Phenomenon.

Unit - III (2 Questions)

Definition and Examples of Gabor Transforms, Basic Properties of Gabor Transforms.

Definition and Examples of Zak Transforms, Basic Properties of Zak Transforms, Balian- Low Theorem.

Unit- IV (2 Questions)

Wavelet Transform, Continuous Wavelet Transforms, Basic Properties of Wavelet Transforms, Discrete Wavelet Transforms, Partial Discrete Wavelet Transforms, Maximal Overlap Discrete Wavelet Transforms.

Note : The question paper will consist of **five** units. Each of the first four units will contain **two** questions from unit **I , II , III , IV** respectively and the students shall be asked to attempt **one** question from each unit. Unit five will contain

eight to ten short answer type questions without any internal choice covering the entire syllabus and shall be **compulsory**.

Books Recommended

1. K. Ahmad and F. A. Shah, Introduction to Wavelet Analysis with Applications, Anamaya Publishers, 2008.
2. Eugenio Hernandez and Guido Weiss, A first Course on Wavelets, CRC Press, New York, 1996.
3. C.K. Chui, An Introduction to Wavelets, Academic Press, 1992.
4. I. Daubechies, Ten Lectures on Wavelets, CBS-NSF Regional Conferences in Applied Mathematics, 61, SIAM, 1992.
5. Y. Meyer, Wavelets, Algorithms and Applications (translated by R.D. Rayan, SIAM, 1993).

12MM 514 (Option A₁₅) : Sobolev Spaces -I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Distributions – Test function spaces and distributions, convergence distributional derivatives.

Unit-II (2 Questions)

Fourier Transform – L^1 -Fourier transform. Fourier transform of a Gaussian, L^2 -Fourier transform, Inversion formula. L^p -Fourier transform, Convolutions.

Unit-III (2 Questions)

Sobolev Spaces - The spaces $W^{1,p}_\infty(\Omega)$ and $W^{1,p}(\Omega)$. Their simple characteristic properties, density results. Min and Max of $W^{1,p}$ – functions. The space $H^1(\Omega)$ and its properties, density results.

Unit-IV (2 Questions)

Imbedding Theorems - Continuous and compact imbeddings of Sobolev spaces into Lebesgue spaces. Sobolev Imbedding Theorem, Rellich – Kondrasov Theorem.

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

Books Recommended

1. R.A. Adams, Sobolev Spaces, Academic Press, Inc. 1975.
2. S. Kesavan, Topics in Functional Analysis and Applications, Wiley Eastern Limited, 1989.
3. A. Kufner, O. John and S. Fucik, Function Spaces, Noordhoff International Publishing, Leyden, 1977.
4. A. Kufner, Weighted Sobolev Spaces, John Wiley & Sons Ltd., 1985.
5. E.H. Lieb and M. Loss, Analysis, Narosa Publishing House, 1997.
6. R.S. Pathak, A Course in Distribution Theory and Applications, Narosa Publishing House, 2001.

12MM 514 (Option B₁₁) : Mechanics of Solids-I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Cartesian tensors of different order. Properties of tensors. Symmetric and skew-symmetric tensors. Isotropic tensors of different orders and relation between them. Tensor invariants. Eigen-values and eigen vectors of a second order tensor. Scalar, vector, tensor functions. Comma notation. Gradient, divergence and curl of a tensor field.

Unit-II(2 Questions)

Analysis of Stress : Stress vector, stress components. Cauchy equations of equilibrium. Stress tensor. Symmetry of stress tensor. Stress quadric of Cauchy. Principal stress and invariants. Maximum normal and shear stresses. Mohr's diagram. Examples of stress.

Unit-III (2 Questions)

Analysis of Strain : Affine transformations. Infinitesimal affine deformation. Geometrical interpretation of the components of strain. Strain quadric of Cauchy. Principal strains and invariants. General infinitesimal deformation. Saint-Venant's equations of Compatibility. Finite deformations. Examples of uniform dilatation, simple extension and shearing strain.

Unit-IV (2 Questions)

Equations of Elasticity : Generalized Hooke's law. Hooke's law in media with one plane of symmetry, orthotropic and transversely isotropic media, Homogeneous isotropic media. Elastic moduli for isotropic media. Equilibrium and dynamic equations for an isotropic elastic solid. Beltrami-Michell compatibility equations. Strain energy function. Clapeyron's theorem. Saint-Venant's Principle.

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

1. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1977.
2. Teodar M. Atanackovic and Ardeshiv Guran, Theory of Elasticity for Scientists and Engineers Birkhausev, Boston, 2000.
3. Y.C. Fung, Foundations of Solid Mechanics, Prentice Hall, New, Delhi, 1965.
4. Jeffreys, H. , Cartesian tensor.
5. Shanti Narayan, Text Book of Tensors, S. chand & co.
6. Saada, A.S., Elasticity- Theory and applications, Pergamon Press, New York.
7. A.E.H. Love, A Treatise on a Mathematical Theory of Elasticity, Dover Pub., New York.
8. D.S. Chandersekhariah and L. Debnath, Continuum Mechanics, Academic Press, 1994.

12MM 514 (Option B₁₂) : Continuum Mechanics - I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Cartesian tensors and their elementary properties.

Analysis of Stress : Stress vector, stress components, Cauchy equations of equilibrium, stress tensor, symmetry of stress tensor, principal stress and invariants, maximum normal and shear stresses.

Unit-II (2 Questions)

Analysis of Strain : Affine transformation, infinitesimal affine deformation, geometric interpretation of the components of strain, principal strains and invariants, general infinitesimal deformation, equations of compatibility, finite deformations.

Unit-III(2 Questions)

Equations of Elasticity : Generalized Hooke's law, Hooke's law in media with one plane of symmetry, orthotropic and transversely isotropic media, Homogeneous isotropic media, elastic moduli for isotropic media, equilibrium and dynamical equations for an isotropic elastic solid, Beltrami – Michell compatibility equations.

Unit-IV (2 Questions)

Two-Dimensional Elasticity : Plane strain, plane stress, generalized plane stress, Airy stress function, problem of half-plane loaded by uniformly distributed load, problem of thick wall tube under the action of internal and external pressures, Rotating shaft.

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

Books Recommended

1. S. Valliappan, Continuum Mechanics, Fundamentals, Oxford & IBH Publishing Company, 1981.
2. G.T. Mase and G.E. Mase, Continuum Mechanics for Engineers, CRC Press, 1999.
3. Atanackovic, T.M. A. Guran, Theory of Elasticity for scientists and Engineers, Birkhausev, 2000.
4. D.S. Chandrasekharaiah, Continuum Mechanics, Academic Press, Prism Books Pvt. Ltd., Bangalore.
5. L.S. Srinath, Advanced Mechanics of Fields, Tata McGraw-Hill, New Delhi.

12MM 514 (Option B₁₃) : Computational Fluid Dynamics- I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Basic equations of Fluid dynamics. Analytic aspects of partial differential equations- classification, boundary conditions, maximum principles, boundary layer theory.

Unit-II (2 Questions)

Finite difference and Finite volume discretizations. Vertex-centred discretization. Cell-centred discretization. Upwind discretization. Nonuniform grids in one dimension.

Unit-III (2 Questions)

Finite volume discretization of the stationary convection-diffusion equation in one dimension. Schemes of positive types. Defect correction. Non-stationary convection-diffusion equation. Stability definitions. The discrete maximum principle.

Unit-IV (2 Questions)

Incompressible Navier-Stokes equations. Boundary conditions. Spatial discretization on collocated and on staggered grids. Temporal discretization on staggered grid and on collocated grid.

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

Books Recommended

1. P. Wesseling : Principles of Computational Fluid Dynamics, Springer Verlag, 2000.
2. J.F. Wendt, J.D. Anderson, G. Degrez and E. Dick : Computational Fluid Dynamics : An Introduction, Springer-Verlag, 1996.

3. J.D. Anderson, Computational Fluid Dynamics : The basics with applications, McGraw-Hill, 1995.
4. K. Muralidher and T. Sundarajan : Computational Fluid Flow and Heat Transfer, Narosa Pub. House.
5. T.J. Chung : Computational Fluid Dynamics, Cambridge Uni. Press.
6. J.N. Reddy : An introduction to the Finite Element Methods, McGraw Hill International Edition, 1985.

12MM 514 (Option B₁₄) : Difference Equations- I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Introduction, Difference Calculus – The difference operator, Summation, Generating functions and approximate summation.

Linear Difference Equations - First order equations. General results for linear equations.

Unit-II (2 Questions)

Equations with constant coefficients. Applications. Equations with variable coefficients.

Stability Theory - Initial value problems for linear systems. Stability of linear systems.

Unit-III (2 Questions)

Stability of nonlinear systems. Chaotic behaviour.

Asymptotic methods - Introduction, Asymptotic analysis of sums. Linear equations. Nonlinear equations.

Unit-IV (2 Questions)

Self-adjoint second order linear equations –Introduction. Sturmian Theory. Green's functions. Disconjugacy. The Riccati Equations. Oscillation.

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

Books Recommended

1. Walter G. Kelley and Allan C. Peterson- Difference Equations. An Introduction with Applications, Academic Press Inc., Harcourt Brace Jorandovich Publishers, 1991.
2. Calvin Ahlbrandt and Allan C. Peterson. Discrete Hamiltonian Systems, Difference Equations, Continued Fractions and Riccati Equations. Kluwer, Boston, 1996.

12MM 514 (Option B₁₅) : Information Theory- I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Measure of Information – Axioms for a measure of uncertainty. The Shannon entropy and its properties. Joint and conditional entropies. Transformation and its properties. Axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.

Unit-II (2 Questions)

Noiseless coding - Ingredients of noiseless coding problem. Uniquely decipherable codes. Necessary and sufficient condition for the existence of instantaneous codes. Construction of optimal codes.

Unit-III (2 Questions)

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

Unit-IV (2 Questions)

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

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

Books Recommended

1. R. Ash, Information Theory, Interscience Publishers, New York, 1965.
2. F.M. Reza, An Introduction to Information Theory, MacGraw-Hill Book Company Inc., 1961.
3. J. Aczela dn Z. Daroczy, On Measures of Information and their Characterizations, Academic Press, New York.

12MM 515 (Option C₁₁) : Theory of Linear Operators -I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Spectral theory in normed linear spaces, resolvent set and spectrum, spectral properties of bounded linear operators, Properties of resolvent and spectrum, Spectral mapping theorem for polynomials, Spectral radius of a bounded linear operator on a complex Banach space.

Unit-II (2 Questions)

Elementary theory of Banach algebras. Properties of Banach algebras. General properties of compact linear operators. Spectral properties of compact linear operators on normed spaces.

Unit-III (2 Questions)

Behaviour of compact linear operators with respect to solvability of operator equations. Fredholm type theorems. Fredholm alternative theorem. Fredholm alternative for integral equations. Spectral properties of bounded self-adjoint linear operators on a complex Hilbert space.

Unit-IV (2 Questions)

Positive operators, Monotone sequence theorem for bounded self-adjoint operators on a complex Hilbert space. Square roots of a positive operator. Projection operators, Spectral family of a bounded self-adjoint linear operator and its properties.

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

Books Recommended

1. E. Kreyszig, Introductory Functional Analysis with Applications, John-Wiley & Sons, New York, 1978.
2. P.R. Halmos, Introduction to Hilbert Space and the Theory of Spectral Multiplicity, Second-Edition, Chelsea Publishing Co., New York, 1957.
3. N. Dunford and J.T. Schwartz, Linear Operators -3 Parts, Interscience/Wiley, New York, 1958-71.
4. G. Bachman and L. Narici, Functional Analysis, Academic Press, York, 1966.

12MM 515 (Option C₁₂) : Analytical Number Theory-I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Distribution of primes. Fermat's and Mersenne numbers, Farey series and some results concerning Farey series. Approximation of irrational numbers by rationals, Hurwitz's theorem. Irrationality of e and π . (Relevant portions from the Books Recommended at Sr. No. 1 and 4)

Unit-II (2 Questions)

Diophantine equations $ax + by = c$, $x^2 + y^2 = z^2$ and $x^4 + y^4 = z^4$. The representation of number by two or four squares. Warig's problem, Four square theorem, the numbers $g(k)$ & $G(k)$. Lower bounds for $g(k)$ & $G(k)$. Simultaneous linear and non-linear congruences Chinese Remainder Theorem and its extension. (Relevant portions from the Books Recommended at Sr. No. 1 and 4)

Unit-III (2 Questions)

Quadratic residues and non-residues. Legendre's Symbol. Gauss Lemma and its applications. Quadratic Law of Reciprocity Jacobi's Symbol. The arithmetic in \mathbb{Z}_n . The group U_n . Congruences with prime power modulus, primitive roots and their existence. (Scope as in Book at Sr. No. 5)

Unit-IV (2 Questions)

The group U_p^n (p -odd) and U_2^n . The group of quadratic residues Q_n , quadratic residues for prime power moduli and arbitrary moduli. The algebraic structure of U_n and Q_n . (Scope as in Book at Sr. No. 5)

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

Books Recommended

1. Hardy, G.H. and Wright, E.M., An Introduction to the Theory of Numbers
2. Burton, D.M., Elementary Number Theory.
3. McCoy, N.H., The Theory of Number by McMillan.
4. Niven, I. And Zuckermann, H.S., An Introduction to the Theory of Numbers.
5. Gareth, A. Jones and J. Mary Jones, Elementary Number Theory, Springer Ed. 1998.

12MM 515 (Option C₁₃) : Fuzzy Sets and their Applications -I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Definition of Fuzzy Set, Expanding Concepts of Fuzzy Set, Standard Operations of Fuzzy Set, Fuzzy Complement, Fuzzy Union, Fuzzy Intersection, Other Operations in Fuzzy Set, T- norms and T- conorms. (Chapter 1 of [1])

Unit-II (2 Questions)

Product Set, Definition of Relation, Characteristics of Relation, Representation Methods of Relations, Operations on Relations, Path and Connectivity in Graph, Fundamental Properties, Equivalence Relation, Compatibility Relation, Pre-order Relation, Order Relation, Definition and Examples of Fuzzy Relation, Fuzzy Matrix, Operations on Fuzzy Relation, Composition of Fuzzy Relation, α - cut of Fuzzy Relation, Projection and Cylindrical Extension, Extension by Relation, Extension Principle, Extension by Fuzzy Relation, Fuzzy distance between Fuzzy Sets. (Chapter 2,3 of [1])

Unit-III (2 Questions)

Graph and Fuzzy Graph, Fuzzy Graph and Fuzzy Relation, α - cut of Fuzzy Graph, Fuzzy Network, Reflexive Relation, Symmetric Relation, Transitive Relation, Transitive Closure, Fuzzy Equivalence Relation, Fuzzy Compatibility Relation, Fuzzy Pre-order Relation, Fuzzy Order Relation, Fuzzy Ordinal Relation, Dissimilitude Relation, Fuzzy Morphism, Examples of Fuzzy Morphism. (Chapter 4 of [1])

Unit-IV (2 Questions)

Interval, Fuzzy Number, Operation of Interval, Operation of α - cut Interval, Examples of Fuzzy Number Operation,, Definition of Triangular Fuzzy Number, Operation of Triangular Fuzzy Number, Operation of General Fuzzy Numbers, Approximation of Triangular Fuzzy Number, Operations of Trapezoidal Fuzzy Number, Bell Shape Fuzzy Number.

Function with Fuzzy Constraint, Propagation of Fuzziness by Crisp Function, Fuzzifying Function of Crisp Variable, Maximizing and Minimizing Set, Maximum Value of Crisp Function, Integration and Differentiation of Fuzzy Function. (Chapter 5,6 of [1])

Note : The question paper will consist of **five** units. Each of the first four units will contain **two** questions from unit **I , II , III , IV** respectively and the students shall be asked to attempt **one** question from each unit. Unit five will contain

eight to ten short answer type questions without any internal choice covering the entire syllabus and shall be **compulsory**.

Books Recommended

1. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.
2. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 1991.
3. John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education.

12MM 515 (Option C₁₄) : Bases in Banach Spaces –I

Max. Marks : 80

Time : 3 hours

Unit-I (2Questions)

Hamel bases. The coefficient functionals associated to a basis. Schauder bases. Bounded bases and normalized bases. Examples of bases in concrete Banach spaces.

Unit-II (2Questions)

Biorthogonal systems. Associated sequences of partial sum operators -E-complete, regular and irregular biorthogonal systems. Characterizations of regular biorthogonal systems. Basic sequences. Banach space (separable or not) and basic sequence.

Unit-III (2Questions)

Some types of linear independence of sequences - Linearly independent (finitely) W-linearly independent and minimal sequences of elements in Banach spaces. Their relationship together with examples and counter-examples.

Problem of uniqueness of basis - Equivalent bases, Stability theorems of Paley-Winer type. Block basic sequences with respect to a sequence (basis) and their existence. Bessaga-Pelczynski theorem.

Unit-IV (2 Questions)

Properties of strong duality. Weak bases and weak Schauder bases in a Banach space. Weak basis theorem. Weak* bases in conjugate spaces and their properties.

Shrinking bases and boundedly complete bases together with their relationship.

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

Books Recommended

1. Jurg t. Marti, Introduction to Theory of Bases, Springer Tracts in Natural Philosophy 18, 1969.
2. Ivan Singer, Bases in Banach Spaces I, Springer-Verlag, Berlin, Vol. 154 1970.
3. Ivan Singer, Bases in Banach Spaces II, Springer-Verlag, Berlin, 1981.
4. J. Lindenstrauss and I. Tzafriri, Classical banach Spaces (Sequence spaces), Springer Verlag, Berlin, 1977.
5. Ivan Singer, Best Approximation in Normed Linear Spaces by Elements of Linear Spaces, Springer-Verlag, Berlin, 1970.

12MM 514 (Option C₁₅) : Algebraic Topology -I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Fundamental group function, homotopy of maps between topological spaces, homotopy equivalence, contractible and simple connected spaces, fundamental groups of S^1 , and $S^1 \times S^1$ etc.

Unit-II (2 Questions)

Calculation of fundamental group of S^n , $n > 1$ using Van Kampen's theorem, fundamental groups of a topological group. Brouwer's fixed point theorem, fundamental theorem of algebra, vector fields on planer sets. Frobenius theorem for 3×3 matrices.

Unit-III (2 Questions)

Covering spaces, unique path lifting theorem, covering homotopy theorems, group of covering transformations, criterion of lifting of maps in terms of fundamental groups, universal covering, its existence, special cases of manifolds and topological groups.

Unit-IV (2 Questions)

Singular homology, reduced homology, Eilenberg Steenrod axioms of homology (no proof for homotopy invariance axiom, excision axiom and exact sequence axiom) and their application, relation between fundamental group and first homology.

Calculation of homology of S^n , Brouwer's fixed point theorem for $f : E^n \rightarrow E^n$, application spheres, vector fields, Mayer-Vietoris sequence (without proof) and its applications.

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

Books Recommended

1. James R. Munkres, Topology – A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 1978.
2. Marwin J. Greenberg and J.R. Harper, Algebraic Topology – A First Course, Addison-Wesley Publishing Co., 1981.
3. W.S. Massey, Algebraic Topology – An Introduction, Harcourt, Brace and World Inc. 1967, SV, 1977.

12MM 515 (Option D₁₁) : Fluid Dynamics-I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Kinematics - Velocity at a point of a fluid. Eulerian and Lagrangian methods. Stream lines, path lines and streak lines. Velocity potential. Irrotational and rotational motions. Vorticity and circulation. Equation of continuity. Boundary surfaces. Acceleration at a point of a fluid. Components of acceleration in cylindrical and spherical polar co-ordinates.

Unit-II (2 Questions)

Pressure at a point of a moving fluid. Euler's and Lagrange's equations of motion. Equations of motion in cylindrical and spherical polar co-ordinates.

Bernoulli's equation. Impulsive motion. Kelvin's circulation theorem. Vorticity equation. Energy equation for incompressible flow.

Unit-III (2 Questions)

Acyclic and cyclic irrotational motions. Kinetic energy of irrotational flow. Kelvin's minimum energy theorem. Mean potential over a spherical surface. K.E. of infinite fluid. Uniqueness theorems. Axially symmetric flows. Liquid streaming past a fixed sphere. Motion of a sphere through a liquid at rest at infinity. Equation of motion of a sphere. K.E. generated by impulsive motion. Motion of two concentric spheres.

Unit-IV (2 Questions)

Three-dimensional sources, sinks and doublets. Images of sources, sinks and doublets in rigid impermeable infinite plane and in impermeable spherical surface. Two dimensional motion, Kinetic energy of acyclic and cyclic irrotational motion. Use of cylindrical polar co-ordinates. Stream function. Axisymmetric flow. Stoke's stream function. Stoke's stream function of basic flows.

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

Books Recommended

1. W.H. Besaint and A.S. Ramasey, A Treatise on Hydromechanics, Part II, CBS Publishers, Delhi, 1988.
2. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985
3. O'Neill, M.E. and Chorlton, F., Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986.
4. S.W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi, 1976.
5. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
6. G.K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.

12MM 515 (Option D₁₂) : Biomechanics- I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Newton's equations of motion. Mathematical modeling. Continuum approach. Segmental movement and vibrations. Lagrange's equations. Normal modes of vibration. Decoupling of equations of motion.

Unit-II (2 Questions)

Flow around an airfoil. Flow around bluff bodies. Steady state aeroelastic problems. Transient fluid dynamics forces due to unsteady motion. Flutter. Kutta-Joukowski theorem. Circulation and vorticity in the wake. Vortex system associated with a finite wing in nonsteady motion. Thin wing in steady flow.

Unit-III (2 Questions)

Blood flow in heart, lungs, arteries, and veins. Field equations and boundary conditions. Pulsatile flow in Arteries. Progressive waves superposed on a steady flow. Reflection and transmission of waves at junctions. Velocity profile of a steady flow in a tube. Steady laminar flow in an elastic tube. Velocity profile of Pulsatile flow. The Reynolds number, Stokes number, and Womersley number. Systematic blood pressure. Flow in collapsible tubes.

Unit-IV (2 Questions)

Micro-and macrocirculation Rheological properties of blood. Pulmonary capillary blood flow. Respiratory gas flow. Intraction between convection and diffusion. Dynamics of the ventilation system.

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

Books Recommended

1. Y.C. Fung, Biomechanics: Motion, Flow, Stress and Growth, Springer-Verlag, New York Inc., 1990.

12MM 515 (Option D₁₃): Integral Equations and Boundary Value Problems-I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Definition of integral equations and their classification. Eigenvalues and eigenfunctions. Convolution integral. Fredholm integral equations of the second kind with separable kernels and their reduction to a system of algebraic equations. Fredholm alternative. Fredholm theorem, Fredholm alternative theorem. An approximate method.

Unit-II (2 Questions)

Method of successive approximations. Iterative scheme for Fredholm integral equations of the second kind. Neumann series, iterated kernels, resolvent kernel, Iterative scheme for Volterra integral equations of the second kind. Conditions of uniform convergence and uniqueness of series solution.

Unit-III (2 Questions)

Classical Fredholm theory. Fredholm's first, second and third theorems. Applications integral equations to ordinary differential equations. Initial value problems transformed to volterra integral equations. Boundary value problems equivalent to Fredholm integral equations. Dirac delta function.

Unit-IV (2 Questions)

Construction of Green's function for a BVP associated with a nonhomogeneous ordinary differential equation of second order with homogeneous boundary conditions by using the method of variation of parameters, Basic four properties of the Green's function. Alternative procedure for construction of a Green's function by using its basic four properties. Green's function approach for IVP for second

order equations. Green's function for higher order differential equations. Modified Green's function.

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

Books Recommended

1. Kanwal, R.P., Linear Integral Equations – Theory and Technique, Academic Press, 1971.
2. Kress, R., Linear Integral Equations, Springer-Verlag, New York, 1989.
3. Jain, D.L. and Kanwal, R.P., Mixed Boundary Value Problems in Mathematical Physics.
4. Smirnov, V.I., Integral Equations and Partial Differential Equations, Addison-Wesley, 1964.
5. Jerri, A.J., Introduction to Integral Equations with Applications, Second Edition, John-Wiley & Sons, 1999.
6. Kanwal, R.P., Linear Integration Equations, (2nd Ed.) Birkhauser, Boston, 1997.

12MM 515 (Option D₁₄) : Mathematics for Finance and Insurance-I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Financial Management – AN overview. Nature and Scope of Financial Management. Goals of Financial Management and main decisions of financial management. Difference between risk, speculation and gambling.

Time value of Money - Interest rate and discount rate. Present value and future value- discrete case as well as continuous compounding case. Annuities and its kinds.

Unit-II (2 Questions)

Meaning of return. Return as Internal Rate of Return (IRR). Numerical Methods like Newton Raphson Method to calculate IRR. Measurement of returns under uncertainty situations. Meaning of risk. Difference between risk and uncertainty. Types of risks. Measurements of risk. Calculation of security and Portfolio Risk and Return-Markowitz Model. Sharpe's Single Index Model- Systematic Risk and Unsystematic Risk.

Unit-III (2 Questions)

Taylor series and Bond Valuation. Calculation of Duration and Convexity of bonds.

Insurance Fundamentals – Insurance defined. Meaning of loss. Chances of loss, peril, hazard, and proximate cause in insurance. Costs and benefits of insurance to the society and branches of insurance-life insurance and various types of general insurance. Insurable loss exposures- feature of a loss that is ideal for insurance.

Unit-IV (2 Questions)

Life Insurance Mathematics – Construction of Morality Tables. Computation of Premium of Life Insurance for a fixed duration and for the whole life.

Determination of claims for General Insurance – Using Poisson Distribution and Negative Binomial Distribution –the Polya Case.

Determination of the amount of Claims of General Insurance – Compound Aggregate claim model and its properties, and claims of reinsurance. Calculation of a compound claim density function F, recursive and approximate formulae for F.

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

Books Recommended

1. Aswath Damodaran, Corporate Finance - Theory and Practice, John Wiley & Sons, Inc.
2. John C. Hull, Options, Futures, and Other Derivatives, Prentice-Hall of Indian Private Limited.
3. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge University Press.
4. Mark S. Dorfman, Introduction to Risk Management and Insurance, Prentice Hall, Englewood Cliffs, New Jersey.
5. C.D. Daykin, T. Pentikainen and M. Pesonen, Practical Risk Theory for Actuaries, Chapman & Hall.
6. Salih N. Neftci, An Introduction to the Mathematics of Financial Derivatives, Academic Press, Inc.
7. Robert J. Elliott and P. Ekkehard Kopp, Mathematics of Financial Markets, Springer-Verlag, New York Inc.
8. Robert C. Merton, Continuous – Time Finance, Basil Blackwell Inc.
9. Tomasz Rolski, Hanspeter Schmidli, Volker Schmidt and Jozef Teugels, Stochastic Processes for Insurance and Finance, John Wiley & Sons Limited.

12MM 515 (Option D₁₅) : Space Dynamics- I

Max. Marks : 80

Time : 3 hours

Unit-I (2 Questions)

Basic Formulae of a spherical triangle - The two-body Problem : The Motion of the Center of Mass. The relative motion. Kepler's equation. Solution by Hamilton Jacobi theory.

Unit-II (2 Questions)

The Determination of Orbits – Laplace's Gauss Methods.

The Three-Body problem – General Three Body Problem. Restricted Three Body Problem.

Unit-III (2 Questions)

Jacobi integral. Curves of Zero velocity. Stationary solutions and their stability.

The n-Body Problem – The motion of the centre of Mass. Classical integrals.

Unit-IV (2 Questions)

Perturbation – Osculating orbit, Perturbing forces, Secular & Periodic perturbations. Lagrange's Planetary Equations in terms of perturbing forces and in terms of a perturbed Hamiltonian.

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

Books Recommended

1. J.M. A. Danby, Fundamentals of Celestial Mechanics. The MacMillan Company, 1962.
2. E. Finlay, Freundlich, Celestial Mechanics. The MacMillan Company, 1958.
3. Theodore E. Sterne, An Introduction of Celestial Mechanics, Intersciences Publishers. INC., 1960.
4. Arigelo Miele, Flight Mechanics – Vol . 1 - Theory of Flight Paths, Addison-Wesley Publishing Company Inc., 1962.

SEMESTER-IV

Paper Code	Title of the Paper	Theory Marks	Internal-Assessment Marks	Practicals Marks	Total
12MM 521	Functional Analysis-II	80	20	-	100
12MM 522	Classical Mechanics	80	20	-	100
12MM 523	Complex Analysis-II	80	20	-	100
12MM 524	One paper out of either Group A ₂ or Group B ₂	80	20	-	100
12MM 525	One paper out of either Group C ₂ or Group D ₂	80	20	-	100
Total Marks Semester-IV					500
Total Marks Semester-III					500
Total Marks Semester-II					500
Total Marks Semester-I					500
GRAND TOTAL					2000

Group A₂ (Pre-requisite paper A_{1i})

- A₂₁ Advanced Functional Analysis-II
- A₂₂ Advanced Discrete Mathematics-II
- A₂₃ Algebraic Coding Theory-II
- A₂₄ Wavelets-II
- A₂₅ Sobolev Spaces-II
- A₂₆ Frames and Riesz Bases-II

Group B₂ (Pre-requisite paper B_{1i})

- B₂₁ Mechanics of Solids-II
- B₂₂ Continuum Mechanics-II
- B₂₃ Computational Fluid Dynamics-II
- B₂₄ Difference Equations-II
- B₂₅ Information Theory-II

Group C₂ (Pre-requisite : Group A₂ and paper C_{1i})

- C₂₁ Theory of Linear Operators-II
- C₂₂ Analytical Number Theory-II
- C₂₃ Fuzzy Sets and Applications-II
- C₂₄ Bases in Banach Spaces-II
- C₂₅ Algebraic Topology-II

Group D₂ (Pre-requisite : Group B₂ and paper D_{1i})

- D₂₁ Fluid Dynamics-II
- D₂₂ Bio-Mechanics-II
- D₂₃ Integral Equations and Boundary Value Problems-II
- D₂₄ Mathematics of Finance and Insurance-II
- D₂₅ Space Dynamics-II

Note 1: The marks of internal assessment of each paper shall be split as under :

- A) One class test of 10 marks. The class test will be held in the middle of the semester.
- B) Assignment & Presentation : 5 marks
- C) Attendance : 5 marks
 - 65% but upto 75% : 1 marks
 - More than 75% but upto 85% : 2 marks
 - More than 85% but upto 90% : 3 marks
 - More than 90% but upto 95% : 4 marks
 - Above 95% : 5 marks

Note 2: The syllabus of each paper will be divided into **four** units of **two** questions each. The question paper will consist of **five** units. Each of the first four units will contain two questions and the students shall be asked to attempt **one** question from each unit. Unit five of each question paper shall contain **eight to ten** short answer type questions without any internal choice and it shall be covering the entire syllabus. As such unit five shall be **compulsory**.

Note 3: As per UGC Recommendations, the teaching program shall be supplemented by tutorials and problem solving sessions for each theory paper. For this purpose, tutorial classes shall be held for each theory paper in groups of 8 students for half-hour per week.

Note 4: Optional papers can be offered subject to availability of requisite resources/ faculty.

Syllabus- 4th SEMESTER

12MM 521 : Functional Analysis –II

Max. Marks : 80

Time : 3 Hours

Unit-I (2 Questions)

Signed measure, Hahn decomposition theorem, Jordan decomposition theorem, Mutually signed measure, Radon – Nikodyn theorem Lebesgue decomposition, Lebesgue - Stieltjes integral, Product measures, Fubini's theorem.

Unit-II (2 Questions)

Baire sets, Baire measure, continuous functions with compact support, Regularity of measures on locally compact spaces, Riesz-Markoff theorem.

Hilbert Spaces: Inner product spaces, Hilbert spaces, Schwarz's inequality, Hilbert space as normed linear space.

Unit-III (2 Questions)

Convex sets in Hilbert spaces, Projection theorem. Orthonormal sets, Bessel's inequality, Parseval's identity, conjugate of a Hilbert space, Riesz representation theorem in Hilbert spaces.

Unit-IV (2 Questions)

Adjoint of an operator on a Hilbert space, Reflexivity of Hilbert space, Self-adjoint operators, Positive and projection operators, Normal and unitary operators, Projections on Hilbert space, Spectral theorem on finite dimensional space.

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

Books Recommended

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

Max. Marks : 80

Time : 3 hours

Unit –I(2 Question)

Free & constrained systems, constraints and their classification, holonomic and non-holonomic systems, degree of freedom and generalised coordinates, virtual displacement and virtual work, statement of principle of virtual work (PVW), possible velocity and possible acceleration, D' Alembert's principle,

Lagrangian Formulation : Ideal constraints, general equation of dynamics for ideal constraints, Lagrange's equations of the first kind.

Unit –II(2 Question)

Independent coordinates and generalized forces, Lagrange's equations of the second kind, generalized velocities and accelerations. Uniqueness of solution, variation of total energy for conservative fields.

Lagrange's variable and Lagrangian function $L(t, q_i, \dot{q}_i)$, Lagrange's equations for potential forces, generalized momenta p_i , Hamiltonian variable and Hamiltonian function $H(t, q_i, p_i)$, Donkin's theorem, ignorable coordinates.

Unit -III(2 Question)

Hamilton canonical equations, Routh variables and Routh function R , Routh's equations, Poisson Brackets and their simple properties, Poisson's identity, Jacobi – Poisson theorem.

Hamilton action and Hamilton's principle, Poincare – Carton integral invariant, Whittaker's equations, Jacobi's equations, Lagrangian action and the principle of least action.

Unit -IV(2 Question)

Canonical transformation, necessary and sufficient condition for a canonical transformation, univalent Canonical transformation, free canonical transformation, Hamilton-Jacobi equation, Jacobi theorem, method of separation of

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

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

Books Recommended

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

12MM 523 : Complex Analysis-II

Max. Marks : 80

Time : 3 hours

Unit - I(2 Question)

Integral Functions. Factorization of an integral function. Weierstrass' factorisation theorem. Factorization of sine function. Gamma function and its properties. Stirling formula. Integral version of gamma function. Riemann Zeta function. Riemann's functional equation. . Runge's theorem. Mittag-Leffler's theorem.

Unit - II(2 Question)

Analytic Continuation. Natural Boundary. Uniqueness of direct analytic continuation. Uniqueness of analytic continuation along a curve. Power series method of analytic continuation. Schwarz Reflection principle. Germ of an analytic function.

Monodromy theorem and its consequences. Harmonic functions on a disk. Poisson kernel. The Dirichlet problem for a unit disc.

Unit - III(2 Question)

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

Unit -IV(2 Question)

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

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

Books Recommended

1. H.A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
2. J.B. Conway, Functions of one Complex variable, Springer-Verlag, International student-Edition, Narosa Publishing House, 1980.
3. Liang-shin Hann & Bernard Epstein, Classical Complex Analysis, Jones and Bartlett Publishers International, London, 1996.
4. E.T. Copson, An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, London.
5. E.C. Titchmarsh, The Theory of Functions, Oxford University Press, London.
6. L.V. Ahlfors, Complex Analysis, McGraw Hill, 1979.
7. S. Lang, Complex Analysis, Addison Wesley, 1977.
8. Mark J. Ablowitz and A.S. Fokas, Complex Variables : Introduction and Applications, Cambridge University Press, South Asian Edition, 1998.
9. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 1997.

12MM 524 (Option A₂₂) Advanced Discrete Mathematics II

Max. Marks : 80

Time : 3 Hours

Unit- I (2 Questions)

Formal Logic – Statements. Symbolic Representation and Tautologies. Quantifier, Predicates and Validity. Propositional Logic.

Unit -II (2 Questions)

Semigroups & Monoids-Definitions and Examples of Semigroups and Monoids (including those pertaining to concatenation operation). Homomorphism of semigroups and monoids. Congruence relation and Quotient Semigroups. Subsemigroup and submonoids. Direct products. Basic Homomorphism Theorem. Pigeonhole principle, principle of inclusion and exclusion, derangements.

Unit -III (2 Questions)

Lattices- Lattices as partially ordered sets. Their properties. Lattices as Algebraic systems. sublattices, Direct products, and Homomorphisms. Some Special Lattices e.g., Complete. Complemented and Distributive Lattices. Join-irreducible elements. Atoms and Minterms.

Unit -IV (2 Questions)

Boolean Algebras – Boolean Algebras as Lattices. Various Boolean Identities. The switching Algebra example. Subalgebras, Direct Products and Homomorphisms. Boolean Forms and Their Equivalence. Minterm Boolean Forms, Sum of Products Canonical Forms. Minimization of Boolean Functions. Applications of Boolean Algebra to Switching Theory (using AND, OR & NOT gates). The Karnaugh Map method.

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

Books Recommended

1. J.P. Tremblay & R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Co., 1997.
2. J.L. Gersting, Mathematical Structures for Computer Science, (3rd edition), Computer Science Press, New York.

3. Seymour Lipschutz, Finite Mathematics (International edition 1983), McGraw-Hill Book Company, New York.
4. C.L. Liu, Elements of Discrete Mathematics, McGraw-Hill Book Co.
5. Babu Ram, Discrete Mathematics, Vinayak Publishers and Distributors, Delhi, 2004.

12MM 524 (Option A₂₃) : Algebraic Coding Theory-II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Cyclic Codes. Cyclic Codes as ideals. Matrix Description of Cyclic Codes. Hamming and Golay Codes as Cyclic Codes. Error Detection with Cyclic Codes. Error-Correction procedure for Short Cyclic Codes. Short-ended Cyclic Codes. Pseudo Cyclic Codes.

Unit -II (2 Questions)

Quadratic residue codes of prime length, Hadamard Matrices and non-linear Codes derived from them. Product codes. Concatenated codes.

Unit -III (2 Questions)

Code Symmetry. Invariance of Codes under transitive group of permutations. Bose-Chaudhary-Hoquenghem (BCH) Codes. BCH bounds. Reed-Solomon (RS) Codes. Majority-Logic Decodable Codes. Majority- Logic Decoding. Singleton bound. The Griesmer bound.

Unit -IV (2 Questions)

Maximum – Distance Separable (MDS) Codes. Generator and Parity-check matrices of MDS Codes. Weight Distribution of MDS code. Necessary and Sufficient conditions for a linear code to be an MDS Code. MDS Codes from RS codes. Abramson Codes. Closed-loop burst-error correcting codes (Fire codes). Error Locating Codes.

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

Books Recommended

1. Ryamond Hill, A First Course in Coding Theory, Oxford University Press, 1986.
2. Man Young Rhee, Error Correcting Coding Theory, McGraw Hill Inc., 1989.
3. W.W. Peterson and E.J. Weldon, Jr., Error-Correcting Codes. M.I.T. Press, Cambridge Massachusetts, 1972.
4. E.R. Berlekamp, Algebraic Coding Theory, McGraw Hill Inc., 1968.
5. F.J. Macwilliams and N.J.A. Sloane, Theory of Error Correcting Codes, North-Holand Publishing Company.
6. J.H. Van Lint, Introduction to Coding Theory, Graduate Texts in Mathematics, 86, Springer, 1998.

7. L.R. Vermani, Elements of Algebraic Coding Theory, Chapman and Hall, 1996.

12MM 524 (Option A₂₄) : Wavelets –II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Definition and Examples of Multiresolution Analysis, Properties of Scaling Functions and Orthonormal Wavelet Bases, The Haar MRA, Band- Limited MRA, The Meyer MRA.

Unit - II (2 Questions)

Haar Wavelet and its Transform, Discrete Haar Transforms, Shannon Wavelet and its Transform.

Haar Wavelets, Spline Wavelets, Franklin Wavelets, Battle- Lemarie Wavelets, Daubechies Wavelets and Algorithms.

Unit -III (2 Questions)

Biorthogonal Wavelets, Newlands Harmonic Wavelets, Wavelets in Higher Dimensions, Generalized Multiresolution Analysis, Frame Multiresolution Analysis, AB- Multiresolution Analysis, Wavelets Packets, Multiwavelet and Multiwavelet Packets, Wavelets Frames.

Unit -IV (2 Questions)

Applications of Wavelets in Image Processing, Integral Operators, Turbulence, Financial Mathematics : Stock Exchange, Statistics, Neural Networks, Biomedical Sciences.

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

Books Recommended

1. K. Ahmad and F. A. Shah, Introduction to Wavelet Analysis with Applications, Anamaya Publishers, 2008.
2. Eugenio Hernandez and Guido Weiss, A first Course on Wavelets, CRC Press, New York, 1996.
3. C.K. Chui, An Introduction to Wavelets, Academic Press, 1992.
4. I. Daubechies, Ten Lectures on Wavelets, CBS-NSF Regional Conferences in Applied Mathematics, 61, SIAM, 1992.
5. Y. Meyer, Wavelets, Algorithms and Applications (translated by R.D. Rayan, SIAM, 1993).

12MM 524 (Option A₂₅) : Sobolev Spaces -II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Other Sobolev Spaces - Dual Spaces, Fractional Order Sobolev spaces, Trace spaces and trace theory.

Unit -II (2 Questions)

Weight Functions - Definition, motivation, examples of practical importance. Special weights of power type. General Weights.

Weighted Spaces - Weighted Lebesgue space $P(\Omega, \sigma)$, and their properties.

Unit -III (2 Questions)

Domains - Methods of local coordinates, the classes C^0 , $C^{0,k}$, Holder's condition, Partition of unity, the class $K(x_0)$ including Coneproperty.

Unit -IV(2 Questions)

Inequalities – Hardy inequality, Jensen's inequality, Young's inequality, Hardy-Littlewood - Sobolev inequality, Sobolev inequality and its various versions.

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

Books Recommended

1. R.A. Adams, Sobolev Spaces, Academic Press, Inc. 1975.
2. S. Kesavan, Topics in Functional Analysis and Applications, Wiley Eastern Limited, 1989.
3. A. Kufner, O. John and S. Fucik, Function Spaces, Noordhoff International Publishing, Leyden, 1977.
4. A. Kufner, Weighted Sobolev Spaces, John Wiley & Sons Ltd., 1985.
5. E.H. Lieb and M. Loss, Analysis, Narosa Publishing House, 1997.
6. R.S. Pathak, A Course in Distribution Theory and Applications, Narosa Publishing House, 2001.

12MM 524 (Option B₂₁) : Mechanics of Solids-II

Max. Marks : 80

Time : 3 hours

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

Unit-I (2 Questions)

Two-dimensional Problems : Plane strain and Plane stress. Generalized plane stress. Airy stress function for plane strain problems. General solutions of a Biharmonic equation using Fourier transform as well as in terms of two analytic functions. Stresses and displacements in terms of complex potentials. Thick walled tube under external and internal pressures. Rotating shaft.

Unit-II (2 Questions)

Torsion of Beams : Torsion of cylindrical bars. Torsional rigidity. Torsion and stress functions. Lines of shearing stress. Simple problems related to circle, ellipse and equilateral triangle cross-section. Circular groove in a circular shaft.

Extension of Beams: Extension of beams by longitudinal forces. Beam stretched by its own weight.

Unit-III (2 Questions)

Bending of Beams: Bending of Beams by terminal Couples, Bending of a beam by transverse load at the centroid of the end section along a principal axis.

Variational Methods: Variational problems and Euler's equations. The Ritz method-one dimensional case, the Ritz method-Two dimensional case, The Galerkin method, Applications to torsion of beams, The method of Kantorovich. (Relevant topics from the Sokolnikoff's book)

Unit-IV (2 Questions)

Waves: Simple harmonic progressive waves, scalar wave equation, progressive type solutions, plane waves and spherical waves, stationary type solutions in Cartesian and Cylindrical coordinates.

Elastic Waves: Propagation of waves in an unbounded isotropic elastic solid. P, SV and SH waves. Wave propagation in two-dimensions.

Books Recommended:

1. I.S. Sokolnikoff, *Mathematical theory of Elasticity*. Tata McGraw Hill publishing Company Ltd. New Delhi, 1977.

2. Teodar M. Atanackovic and Ardeshiv Guran, *Theory of Elasticity for Scientists and Engineers*, Birkhausev, Boston, 2000.
3. A.K. Mal & S.J. Singh, *Deformation of Elastic Solids*, Prentice Hall, New Jersey, 1991
4. C.A. Coluson, *Waves*
5. A.S. Saada, *Elasticity-Theory and Applications*, Pergamon Press, New York, 1973.
6. D.S. Chandersekhariah and L. Debnath, *Continuum Mechanics*, Academic Press.
7. S. Valliappan, *Continuum Mechanics-Fundamentals*, Oxford & IBH Publishing Company, New Delhi-1981

12MM 524 (Option B₂₂) : Continuum Mechanics - II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Thermoelasticity : Basic concepts of thermoelasticity, Stress-strain relation for thermo-elasticity, Navier equations for thermoelasticity, thermal stresses in a long circular cylinder and in a sphere.

Unit -II (2 Questions)

Viscoelasticity : Viscoelastic models – Maxwell model, Kelvin model and Standard linear solid model. Creep compliance and relaxation modulus, Hereditary integrals, visco-elastic stress-strain relations, correspondence principle and its application to the deformation of a viscoelastic thick-walled tube in plane strain.

Unit -III (2 Questions)

Fluid Dynamics : Viscous stress tensor, Stokesian and Newtonian fluid, Basic equation of viscous flow, Navier stokes equations, specialized fluid, steady flow, irrotational flow, potential flow, Bernollies equation, Kilvin's theorem (As Chapter 7 of the Book by Mase and Mase).

Unit -IV (2 Questions)

Plasticity : Basic concepts, yield criteria, yield surface, equivalent stress and equivalent strain, elastic – plastic stress-strain relation, plastic stress- strain relatin,

plastic flow of anisotropic material, special cases of plane stress, plane strain and axis-symmetry.

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

Books Recommended

1. S. Valliappan, Continuum Mechanics, Fundamentals, Oxford & IBH Publishing Company, 1981.
2. G.T. Mase and G.E. Mase, Continuum Mechanics for Engineers, CRC Press, 1999.
3. Atanackovic, T.M. A. Guran, Theory of Elasticity for scientists and Engineers, Birkhausev, 2000.
4. D.S. Chandrasekharaiah, Continuum Mechanics, Academic Press, Prism Books Pvt. Ltd., Bangalore.
5. L.S. Srinath, Advanced Mechanics of Fields, Tata McGraw-Hill, New Delhi.

12MM 524 (Option B₂₃) : Computational Fluid Dynamics-II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Iterative methods. Stationary methods. Krylov subspace methods. Multigrid methods. Fast Poisson solvers.

Unit -II (2 Questions)

Iterative methods for incompressible Navier-Stokes equations. Shallow-water equations – One and two dimensional cases. Godunov ‘s order barrier theorem.

Unit -III (2 Questions)

Linear schemes. Scalar conservation laws. Euler equation in one space dimension – analytic aspects. Approximate Riemann solver of Roe.

Unit -IV (2 Questions)

Osher scheme. Flux splitting scheme. Numerical stability. Jameson – Schmidt – Turkel scheme. Higher order schemes.

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

Books Recommended

1. P. Wesseling : Principles of Computational Fluid Dynamics, Springer Verlag, 2000.
2. J.F. Wendt, J.D. Anderson, G. Degrez and E. Dick, Computational Fluid Dynamics : An Introduction, Springer-Verlag, 1996.
3. J.D. Anderson, Computational Fluid Dynamics : The basics with applications, McGraw-Hill, 1995.
4. K. Muralidher, Computational Fluid Flow and Heat Transfer, Narosa Pub. House.
5. T.J. Chung, Computational Fluid Dynamics, Cambridge Uni. Press.
6. J.N. Reddy, An introduction to the Finite Element Methods, McGraw Hill International Edition, 1985.

12MM 524 (Option B₂₄) : Difference Equations- II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Sturm-Liouville problems - Introduction, Finite Fourier Analysis. A non-homogeneous problem.

Discrete Calculus of Variations - Introduction. Necessary conditions. Sufficient Conditions and Disconjugacy.

Unit -II (2 Questions)

Nonlinear equations that can be linearized. The z-transform.

Boundary value problems for Nonlinear equations. Introduction. The Lipschitz case. Existence of solutions.

Unit -III (2 Questions)

Boundary value problems for differential equations. Partial Differential Equations.

Unit -IV (2 Questions)

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

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

Books Recommended

1. Walter G. Kelley and Allan C. Peterson- Difference Equations. An Introduction with Applications, Academic Press Inc., Harcourt Brace Joranovich Publishers, 1991.
2. Calvin Ahlbrandt and Allan C. Peterson. Discrete Hamiltonian Systems, Difference Equations, Continued Fractions and Riccati Equations. Kluwer, Boston, 1996.

12MM 524 (Option B₂₅) : Information Theory- II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Some intuitive properties of a measure of entropy – Symmetry, normalization, expansibility, boundedness, recursivity, maximality, stability, additivity, subadditivity, nonnegativity, continuity, branching, etc. and interconnections among them. Axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.

Unit -II (2 Questions)

Information functions, the fundamental equation of information, information functions continuous at the origin, nonnegative bounded information functions, measurable information functions and entropy. Axiomatic characterizations of the Shannon entropy due to Tverberg and Leo.

Unit -III (2 Questions)

The general solution of the fundamental equation of information. Derivations and their role in the study of information functions. The branching property. Some characterisations of the Shannon entropy based upon the branching property. Entropies with the sum property.

Unit -IV (2 Questions)

The Shannon inequality. Subadditive, additive entropies. The Renji entropies. Entropies and mean values. Average entropies and their equality, optimal coding and the Renji entropies. Characterisation of some measures of average code length.

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

Books Recommended

1. R. Ash, Information Theory, Interscience Publishers, New York, 1965.
2. F.M. Reza, An Introduction to Information Theory, MacGraw-Hill Book Company Inc., 1961.
3. J. Aczela dn Z. Daroczy, On Measures of Information and their Characterizations, Academic Press, New York.

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Spectral representation of bounded self adjoint linear operators. Spectral theorem. Properties of the spectral family of a bounded self-adjoint linear operator. Unbounded linear operators in Hilbert Space. Hellinger - Toeplitz theorem. Hilbert adjoint operators.

Unit -II (2 Questions)

Symmetric and self-adjoint linear operators, Closed linear operators and closures. Spectrum of an unbounded self-adjoint linear operator. Spectral theorem for unitary and self-adjoint linear operators. Multiplication operator and differentiation operator.

Unit -III (2 Questions)

Spectral measures. Spectral integrals. Regular spectral measures. Real and complex spectral measures. Complex spectral integrals. Description of the spectral subspaces. Characterization of spectral subspaces. The spectral theorem for bounded normal operators.

Unit -IV(2 Questions)

The Problem of Unitary Equivalence, Multiplicity Functions in Finite-dimensional Spaces, Measures, Boolean Operations on Measures, Multiplicity Functions, The Canonical Example of a Spectral Measure, Finite dimensional Spectral Measures, Simple finite dimensional Spectral Measures.

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

Books Recommended

1. E. Kreyszig, Introductory Functional Analysis with Applications, John-Wiley & Sons, New York, 1978.
2. P.R. Halmos, Introduction to Hilbert Space and the Theory of Spectral Multiplicity, Second-Edition, Chelsea Publishing Co., New York, 1957.
3. N. Dunford and J.T. Schwartz, Linear Operators -3 Parts, Interscience/Wiley, New York, 1958-71.
4. G. Bachman and L. Narici, Functional Analysis, Academic Press, York, 1966.

12MM 525 (Option C₂₂) : Analytical Number Theory-II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Riemann Zeta Function $\zeta(s)$ and its convergence. Application to prime numbers. $\zeta(s)$ as Euler's product. Evaluation of $\zeta(2)$ and $\zeta(2k)$. Dirichlet series with simple properties. Eulers products and Dirichlet products, Introduction to modular forms. (Scope as in Book at Sr. No.5).

Unit -II (2 Questions)

Algebraic Number and Integers : Gaussian integers and its properties. Primes and fundamental theorem in the ring of Gaussian integers. Integers and fundamental theorem in $\mathbb{Q}(\omega)$ where $\omega^3 = 1$. Algebraic fields. Primitive polynomials. The general quadratic field $\mathbb{Q}(\sqrt{m})$, Units of $\mathbb{Q}(\sqrt{2})$. Fields in which fundamental theorem is false. Real and complex Euclidean fields. Fermat's theorem in the ring of Gaussian integers. Primes of $\mathbb{Q}(\sqrt{2})$ and $\mathbb{Q}(\sqrt{5})$ Series of Fibonacci and Lucas. Luca's test for the primality of the mersenne primes. (Relevant sections of Recommended Book at Sr. No. 1).

Unit -III (2 Questions)

Arithmetic functions $\phi(n)$, $\tau(n)$, $\sigma(n)$ and $\sigma_k(n)$, $u(n)$, $N(n)$, $I(n)$. Definition and examples and simple properties. Perfect numbers the Mobius inversion formula. The Mobius function μ_n , The order and average order of the function $\phi(n)$, $\tau(n)$ and $\sigma(n)$. (Scope as in books at Sr. No. 1 and 4).

Unit -IV (2 Questions)

The functions $\Lambda(n)$, $\psi(n)$ and $\vartheta(n)$ Bertrand Postulate, Merten's theorem, Selberg's theorem and Prime number Theorem. (Scope as in Books at Sr. No. 1 and 4).

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

Books Recommended

1. Hardy, G.H. and Wright, E.M., An Introduction to the Theory of Numbers
2. Burton, D.M., Elementary Number Theory.
3. McCoy, N.H., The Theory of Number by McMillan.
4. Niven, I. And Zuckermann, H.S., An Introduction to the Theory of Numbers.

5. Gareth, A. Jones and J. Mary Jones, Elementary Number Theory, Springer Ed. 1998.

12MM 525 (Option C₂₃) : Fuzzy Sets and their Applications - II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Probability Theory, Probability Distribution, Comparison of Probability and Possibility, Fuzzy event, Crisp Probability of Fuzzy Event, Fuzzy Probability of Fuzzy Event, Uncertainty Level of Element, Fuzziness of Fuzzy Set, Measure of Fuzziness, Measure using Entropy, Measure using Metric Distance. (Chapter 7 of book at serial no. 1)

Unit -II (2 Questions)

Proposition Logic, Logic Function, Tautology and Inference Rule, Predicate Logic, Quantifier, Fuzzy Expression, Operators in Fuzzy Expression, Some Examples of Fuzzy Logic Operations, Linguistic Variable, Fuzzy Predicate, Fuzzy Modifier, Fuzzy Truth Values, Examples of Fuzzy Truth Quantifier, Inference and Knowledge Representation, Representation of Fuzzy Predicate by Fuzzy Relation, Representation of Fuzzy Rule.

Extension Principle and Composition, Composition of Fuzzy Sets, Composition of Fuzzy Relation, Example of Fuzzy Composition, Fuzzy if-then Rules, Fuzzy Implications, Examples of Fuzzy Implications, Decomposition of Rule Base, Two-Input/ Single-Output Rule Base, Compositional Rule of Inference, Fuzzy Inference with Rule Base, Inference Methods, Mamdani Method, Larsen Method, Tsukamoto Method, TSK Method. (Chapter 8,9 of book at serial no. 1)

Unit -III (2 Questions)

Advantage of Fuzzy Logic Controller, Configuration of Fuzzy Logic Controller, Choice of State Variables and Control Variables, Fuzzification Interface Component, Data Base, Rule Base, Decision Making Logic, Mamdani Method, Larsen Method, Tsukamoto Method, TSK Method, Mean of Maximum Method, Center of Area Method(COA), Bisector of Area, Lookup Table, Design Procedure of Fuzzy Logic Controller, Application Example of FLC Design, Fuzzy Expert Systems. (Chapter 10 of book at serial no. 1)

Unit -IV (2 Questions)

Applications of Fuzzy Set Theory in Natural, Life and Social Sciences, Engineering, Medicine, Management and Decision Making, Computer Science, System Sciences. (Chapter 6 of book at serial no. 2)

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

Books Recommended

1. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.
2. George J. Klir and Tina A. Folger, Fuzzy Sets, Uncertainty and Information, Prentice Hall of India Private Limited, New Delhi-110 001, 2005.

3. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 1991.
4. John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education.

12MM 525 (Option C₂₄) : Bases in Banach Spaces –II

Max. Marks : 80

Time : 3 hours

Unit -I (2Questions)

Different types of convergence in a Banach space. Unconditional bases. Unconditional basis sequences. Symmetric Bases.

Bases and structure of the space Bases and completeness. Bases and reflexivity.

Unit -II (2 Questions)

Generalized bases. Generalized basic sequences. Boundedly complete generalized bases and shrinking generalized bases. M-Bases (Markusevic bases) and M-Basic sequences.

Bases of subspaces (Decomposition-Existence of a decomposition in Banach spaces. The sequences of co-ordinate projections associated to a decomposition.

Unit -III (2Questions)

Schauder decompositions. Characterization of a Schauder decomposition. Example that a decomposition is not always Schauder. Various possibilities for a Banach space to possess a Schauder decomposition. Shrinking decompositions,

boundedly complete decompositions and unconditional decompositions. Reflexivity of Banach spaces having a Schauder decomposition). Bases and decompositions in the space $C[0,1]$.

Unit -IV (2 Questions)

Best approximation in Banach spaces. Existence and uniqueness of element of best approximation by a subspace. Proximinal subspaces. Semi Chebyshev subspaces and Chebyshev subspaces.

Monotone and strictly monotone bases, co-monotone and strictly co-monotone bases. Examples and counter-examples.

T-norm, K-norm and KT-norm on Banach spaces having bases. Their characterization in terms of monotone and comonotone bases. Various equivalent norms on a Banach space in terms of their bases.

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

Books Recommended

1. Jurg t. Marti, Introduction to Theory of Bases, Springer Tracts in Natural Philosophy 18, 1969.
2. Ivan Singer, Bases in Banach Spaces I, Springer-Verlag, Berlin, Vol. 154 1970.
3. Ivan Singer, Bases in Banach Spaces II, Springer-Verlag, Berlin, 1981.
4. J. Lindenstrauss and I. Tzafriri, Classical Banach Spaces (Sequence spaces), Springer Verlag, Berlin, 1977.
5. Ivan Singer, Best Approximation in Normed Linear Spaces by Elements of Linear Spaces, Springer-Verlag, Berlin, 1970.

12MM 525 (Option C₂₅) : Algebraic Topology -II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Mayer Vietoris sequence and its application to calculation of homology of graphs, torus and compact surface of genus g , collared pairs, construction of spaces by attaching of cells, spherical complexes with examples of S^n , r -leaved rose, torus, \mathbf{RP}^n , \mathbf{CP}^n etc.

Unit -II (2 Questions)

Computation of homology of \mathbf{RP}^n , \mathbf{CP}^n , torus, suspension space, $X \vee Y$, compact surface of genus g and non-orientable surface of genus h using Mayer Vietoris sequence, Betti numbers and Euler characteristics and their calculation for S^n , r -leaved rose, \mathbf{RP}^n , \mathbf{CP}^n , $S^2 \times S^2$, $X + Y$ etc.

Unit -III(2 Questions)

Singular cohomology modules, Kronecker product, connecting homomorphism, contra-functoriality of singular cohomology modules, naturality of connecting homomorphism, exact cohomology sequence of pair, homotopy invariance, excision properties, cohomology of a point. Mayer Vietoris sequence and its application in computation of cohomology of S^n , \mathbf{RP}^n , \mathbf{CP}^n , **torus, compact surface of genus g and non-orientable compact surface.**

Unit -IV (2 Questions)

Compact connected 2-manifolds, their orientability and non-orientability, examples, connect sum, construction of projective space and Klein's bottle from a square, Klein's bottle as unity of two Mobius strips, canonical form of sphere, torus

and projective planes. Klein's bottle. Mobius strip, triangulation of compact surfaces.

Classification theorem for compact surfaces, connected sum of torus and projective plane as the connected sum of three projective planes. Euler characteristic as a topological invariant of compact surfaces. Connected sum formula, 2-manifolds with boundary and their classification Euler characteristic of a bordered surface, models of compact bordered surfaces in \mathbf{R}^3 .

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

Books Recommended

1. James R. Munkres, Topology – A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 1978.
2. Marwin J. Greenberg and J.R. Harper, Algebraic Topology – A First Course, Addison-Wesley Publishing Co., 1981.
3. W.S. Massey, Algebraic Topology – An Introduction, Harcourt, Brace and World Inc. 1967, SV, 1977.

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Irrotational motion in two-dimensions. Complex velocity potential. Milne-Thomson circle theorem. Two-dimensional sources, sinks, doublets and their images. Blasius theorem. Two-dimensional irrotation motion produced by motion of circular, co-axial and elliptical cylinders in an infinite mass of liquid.

Unit -II (2 Questions)

Vortex motion. Kelvin's proof of permanence. Motions due to circular and rectilinear vortices. Spiral vortex. Vortex doublet. Image of a vortex. Centroid of vortices. Single and double infinite rows of vortices. Karman vortex street. Applications of conformal mapping to fluid dynamics.

Unit -III (2 Questions)

Stress components in a real fluid. Relations between rectangular components of stress. Gradients of velocity. Connection between stresses and gradients of velocity. Navier-Stoke's equations of motion. Equations of motion in cylindrical and spherical polar co-ordinates.

Plane Poiseuille and Couette flows between two parallel plates. Theory of lubrication. Flow through tubes of uniform cross-section in form of circle, annulus, ellipse and equilateral triangle under constant pressure gradient. Unsteady flow over a flat plate.

Unit -IV (2 Questions)

Dynamical similarity. Inspection analysis. Reynolds number. Dimensional analysis. Buckingham π -theorem. Prandtl's boundary layer. Boundary layer equation in two-dimensions. Blasius solution. Boundary layer thickness, displacement thickness, momentum thickness. Karman integral conditions. Karman-Pohlmann method. Separation of boundary layer flow.

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

Books Recommended

1. W.H. Besaint and A.S. Ramasey, A Treatise on Hydromechanics, Part II, CBS Publishers, Delhi, 1988.
2. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985
3. O'Neill, M.E. and Chorlton, F., Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986.
4. O'Neill, M.E. and Chorlton, F. , Viscous and Compressible Fluid Dynamics, Ellis Horwood Limited, 1989.
5. S.W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi, 1976.
6. H. Schlichting, Boundary-Layer Theory, McGraw Hill Book Company, New York, 1979.
7. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
8. G.K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.

12MM 525 (Option D₂₂) : Biomechanics- II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Laws of thermodynamics. Gibbs and Gibbs – Duhem equations. Chemical potential. Entropy in a system with heat and mass transfer. Diffusion, filtration, and fluid movement in interstitial space in thermodynamic view. Diffusion from molecular point of view.

Unit -II (2 Questions)

Mass transport in capillaries, tissues, interstitial space, lymphatics, indicator dilution method, and peristalsis. Tracer motion in a model of pulmonary microcirculation.

Unit -III (2 Questions)

Description of internal deformation and forces. Equations of motion in Lagrangian description. Work and strain energy. Calculation of stresses from strain energy function.

Unit -IV (2 Questions)

Stress, strain and stability of organs. Stress and strains in blood vessels. Strength, Trauma, and tolerance. Shock loading and structural response. Vibration and the amplification spectrum of dynamic structural response. Impact and elastic waves.

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

Books Recommended

1. Y.C. Fung, Biomechanics: Motion, Flow, Stress and Growth, Springer-Verlag, New York Inc., 1990.

12MM 525 (Option D₂₃): Integral Equations and Boundary Value Problems-II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Application to Partial Differential Equations. Integral representation formulas for the solutions of the Laplace and Poisson equations. Newtonian single layer and double layer potentials. Interior and exterior Dirichlet and Neumann problems for Laplace equation. Green's function for Laplace equation in a free space as well as in a space bounded by a grounded vessel. Integral equation formulation of BVPs for Laplace equation. The Helmholtz equation. (Relevant topics from the chapters 5 and 6 of the book by R.P. Kanwal).

Unit -II (2 Questions)

Symmetric kernels. Complex Hilbert space. Orthonormal system of functions. Riesz-Fischer theorem (statement only). Fundamental properties of eigenvalues and eigenfunctions for symmetric kernels. Expansion in eigenfunctions and

bilinear form. A necessary and sufficient condition for a symmetric L_2 -kernel to be separable. Hilbert-Schmidt theorem. Definite and indefinite kernels. Mercer's theorem (statement only). Solution of integral equations with symmetric kernels by using Hilbert-Schmidt theorem.

Unit -III (2 Questions)

Singular integral equations. The Abel integral equation. Inversion formula for singular integral equation with kernel of the type $[h(s) - h(t)]^{-\alpha}$ with $0 < \alpha < 1$. Cauchy principal value for integrals. Solution of the Cauchy type singular integral equations. The Hilbert kernel. Solution of the Hilbert-type singular integral equations. Integral transform methods. Fourier transform. Laplace transform. Applications to Volterra integral equations with convolution type kernels. Hilbert transforms and their use to solve integral equations.

Unit -IV (2 Questions)

Applications to mixed BVP's. Two-part BVP's, Three-part BVP's Generalized two-part BVP's. Perturbation method. Its applications to Stokes and Oseen flows, and to Navier-Cauchy equations of elasticity for elastostatic and elastodynamic problems.

(Relevant topics from the chapters 9 to 11 of the book by R.P. Kanwal).

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

Books Recommended

1. Kanwal, R.P., Linear Integral Equations – Theory and Technique, Academic Press, 1971.
2. Kress, R., Linear Integral Equations, Springer-Verlag, New York, 1989.

3. Jain, D.L. and Kanwal, R.P., Mixed Boundary Value Problems in Mathematical Physics.
4. Smirnov, V.I., Integral Equations and Partial Differential Equations, Addison-Wesley, 1964.
5. Jerri, A.J., Introduction to Integral Equations with Applications, Second Edition, John-Wiley & Sons, 1999.
6. Kanwal, R.P., Linear Integration Equations, (2nd Ed.) Birkhauser, Boston, 1997.

12MM 525 (Option D₂₄) : Mathematics for Finance and Insurance-II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Financial Derivatives – Futures. Forward. Swaps and Options. Call and Put Option. Call and Put Parity Theorem. Pricing of contingent claims through Arbitrage and Arbitrage Theorem.

Financial Derivatives – An Introduction; Types of Financial Derivatives- Forwards and Futures; Options and its kinds; and SWAPS.

Unit -II (2 Questions)

The Arbitrage Theorem and Introduction to Portfolio Selection and Capital Market Theory : Static and Continuous – Time Model.

Pricing Arbitrage - A Single-Period option Pricing Model ; Multi-Period Pricing Model - Cox – Ross - Rubinstein Model; Bounds on Option Prices. The Ito's Lemma and the Ito's integral.

Unit -III (2 Questions)

The Dynamics of Derivative Prices - Stochastic Differential Equations (SDEs) - Major Models of SDEs : Linear Constant Coefficient SDEs; Geometric SDEs; Square Root Process; Mean Reverting Process and Ornstein - Uhlenbeck Process.

Martingale Measures and Risk - Neutral Probabilities : Pricing of Binomial Options with equivalent martingale measures.

Unit -IV (2 Questions)

The Black-Scholes Option Pricing Model - using no arbitrage approach, limiting case of Binomial Option Pricing and Risk-Neutral probabilities.

The American Option Pricing - Extended Trading Strategies; Analysis of American Put Options; early exercise premium and relation to free boundary problems.

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

Books Recommended

1. Aswath Damodaran, Corporate Finance - Theory and Practice, John Wiley & Sons, Inc.
2. John C. Hull, Options, Futures, and Other Derivatives, Prentice-Hall of Indian Private Limited.
3. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge University Press.
4. Mark S. Dorfman, Introduction to Risk Management and Insurance, Prentice Hall, Englewood Cliffs, New Jersey.
5. C.D. Daykin, T. Pentikainen and M. Pesonen, Practical Risk Theory for Actuaries, Chapman & Hall.
6. Salih N. Neftci, An Introduction to the Mathematics of Financial Derivatives, Academic Press, Inc.
7. Robert J. Elliott and P. Ekkehard Kopp, Mathematics of Financial Markets, Springer-Verlag, New York Inc.
8. Robert C. Merton, Continuous – Time Finance, Basil Blackwell Inc.

9. Tomasz Rolski, Hanspeter Schmidli, Volker Schmidt and Jozef Teugels, Stochastic Processes for Insurance and Finance, John Wiley & Sons Limited.

12MM 525 (Option D₂₅) : Space Dynamics- II

Max. Marks : 80

Time : 3 hours

Unit -I (2 Questions)

Motion of the moon – The perturbing forces. Perturbations of Keplerian elements of the Moon by the Sun.

Unit -II (2 Questions)

Flight Mechanics – Rocket Performance in a Vacuum. Vertically ascending paths. Gravity Twin trajectories. Multi stage rocket in a Vacuum. Definition pertinent to single stage rocket.

Unit -III (2 Questions)

Performance limitations of single stage rockets, Definitions pertinent to multi stage rockets. Analysis of multi stage rockets neglecting gravity. Analysis of multi stage rockets including gravity.

Unit -IV (2 Questions)

Rocket Performance with Aerodynamic forces. Short range non-lifting missiles. Ascent of a sounding rocket. Some approximate performance of rocket-powered air-craft.

Note : The question paper will consist of **five** units. Each of the first four units will contain **two** questions from unit **I , II , III , IV** respectively and the students

shall be asked to attempt **one** question from each unit. Unit five will contain **eight to ten** short answer type questions without any internal choice covering the entire syllabus and shall be **compulsory**.

Books Recommended

1. J.M. A. Danby, Fundamentals of Celestial Mechanics. The MacMillan Company, 1962.
2. E. Finlay, Freundlich, Celestial Mechanics. The MacMillan Company, 1958.
3. Theodore E. Sterne, An Introduction of Celestial Mechanics, Intersciences Publishers. INC., 1960.
4. Arigelo Miele, Flight Mechanics – Vol . 1 - Theory of Flight Paths, Addison-Wesley Publishing Company Inc., 1962.