Department of Mathematical Sciences
Bodoland University, Kokrajhar

(CBCS Syllabus)
2019

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

COURSE STRUCTURE

Department: Mathematical Sciences, BU.
Programme: MA/MSc in Mathematics

L: Lectures, **T**: Tutorials, **P**: Practical **, CH**:Contact Hours (all per week) **CR**: Credit
C: Core Paper **DSE**: Discipline Specific Elective **OE**: Open Elective

SEMESTER I

Sl No.	Paper Code	Paper Type	Paper Title	L	T	P	CH	CR	Full Marks: (Theory + Practical+ Internal Assessments)	Remark
01	MAT 101	C	Algebra	3	1	0	4	4	100(80+ 0+20)	
02	MAT 102	C	Differential Equations	3	1	0	4	4	100(80+0+20)	
03	MAT 103	C	Mechanics	3	1	0	4	4	100(80+0+20)	
04	MAT 104	C	Real Analysis	3	1	0	4	4	100(80+0+20)	
05	MAT 105	C	Tensor Analysis	3	1	0	4	4	100(80+0+20)	
06	MAT 106	OE	Open Elective I	1	1	0	2	2	50(50+0+0)	
Total Credit								22		

Choices for Open Elective I (MAT 106)

1. Fundamentals of Mathematics. 2. History of Mathematics

SEMESTER II

Sl No.	Paper Code	Paper Type	Paper Title	L	T	P	CH	CR	Full Marks: (Theory + Practical+ Internal Assessments)	Remark
01	MAT 201	C	Complex Analysis	3	1	0	4	4	100(80+ 0+20)	
02	MAT 202	C	Continuum Mechanics	3	1	0	4	4	100(80+0+20)	
03	MAT 203	C	Functional Analysis	3	1	0	4	4	100(80+0+20)	
04	MAT 204	C	General Topology	3	1	0	4	4	100(80+0+20)	
05	MAT 205	C	Mathematical Methods	3	1	0	4	4	100(80+0+20)	
06	MAT 206	OE	Open Elective II	1	1	0	2	2	50(50+0+0)	
Total Credit								22		

Choices for Open Elective II (MAT 206)

1. Applications of Mathematics in Real Life. 2. Mathematics Education

SEMESTER III

Sl No.	Paper Code	Paper Type	Paper Title	L	T	P	CH	CR	Full Marks: (Theory + Practical+ Internal Assessments)	Remark
01	MAT 301	C	Fuzzy Set Theory	3	1	0	4	4	100(80+ 0+20)	
02	MAT 302	C	Graph Theory	3	1	0	4	4	100(80+0+20)	
03	MAT 303	C	Number Theory	3	1	0	4	4	100(80+0+20)	
04	MAT304	C	Numerical Analysis	3	1	0	4	4	100(80+0+20)	
05	MAT 305	C	Special Theory of Relativity	3	1	0	4	4	100(80+0+20)	
05	MAT 306	C	Dissertation				6	6	100(80+0+20)	
Total Credit								26		

SEMESTER IV

Sl No.	Paper Code	Paper Type	Paper Title	L	T	P	CH	CR	Full Marks: (Theory + Practical+ Internal Assessments)	Remark
01	MAT 401	DSE	Elective I	3	1	0	4	4	100(80+ 0+20)	
02	MAT 402	DSE	Elective II	3	1	0	4	4	100(80+0+20)	
03	MAT 403	DSE	Elective III	3	1	0	4	4	100(80+0+20)	
04	MAT404	DSE	Elective IV	3	1	0	4	4	100(80+0+20)	
05	MAT 405	DSE	Dissertation				6	6	100(80+0+20)	
Total Credit								22		

Total 92 credits

A. Choices for Elective I (MAT 401) (choose anyone)

1. Advanced Topology 2. Fluid Dynamics 3. Operator Theory

B. Choices for Elective II (MAT 402) (choose anyone)

1. Advanced Functional Analysis 2. Dynamical Systems 3. Category Theory

C. Choices for Elective III (MAT403) (choose anyone)

1. Fuzzy Logic and Fuzzy Control System 2. Relativity and Cosmology 3. Operations Research

D. Choices for Elective IV (MAT404) (choose anyone)

1. Advanced Graph Theory 2. Advanced Numerical Analysis 3. Advanced Number Theory

Detailed Syllabus

SEMESTER: - I

Paper Code: MAT 101
Paper Title: Algebra
Theory Marks: 80
Internal Marks: 20

Unit-I: Homeomorphism and Automorphism of Groups, Permutation Groups, Cyclic Groups, Sylow's Theorem with applications. **Marks: 20**
Unit-II: Ring Homorphisms, Ideals, maximal and Prime ideals, Ring with zero divisors and Ring without Zero divisor, Definitions and Examples of Integral Domains and Fields. Ring Homomorphisms. **Marks: 20**

Unit-III: Polynomial Rings, Factorization of Polynomials, Divisibility in Integral Domains. Prime and irreducible elements, Principal Ideal Domains, Euclidean Domains. **Marks: 20**
Unit-IV: Construction of fields, Prime field, Extension of fields. **Marks: 20**

Reference Books:
1. Modern Algebra by Surjeet Singh and Qasi Zameeruddin, Vikas Publishing House (Second Edition), New Delhi, 1975.
2. A First Course in Abstract Algebra by John B. Fraleigh, Published by Pearson Education (Singapore) Pte. Ltd.
3.Topics in Algebra, Second edition (Wiley Eastern Ltd.) by I. N. Herstein
4.Joseph A. Gallian, Contemporary Abstract Algebra (Fourth Ed.), Narosa,1999.
5. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra (Second Ed.), Cambridge Univ. Press (Indian Ed.1995).

Paper Code: MAT 102
Paper Title: Differential Equations
Theory Marks: 80
Internal Marks: 20

Unit-I: Solution of 2^{nd} order differential equations with variable coefficients, General theory of homogeneous and non-homogeneous linear ODEs, variation of parameters, method of variation of parameters. Picard's method of successive approximation, problems of Existence and Uniqueness, Riccati's equation. **Marks:20**

Unit-II: Method of series solution of 2^{nd} order differential equations with reference to Legendre, Bessel and Gauss, Hyper geometric equations. Orthogonal set of functions, Sturm-Liouville boundary value problem. **Marks: 20**

Unit-III: Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs. Classification of second order PDEs, Partial differential equation of second order, linear equations with constant coefficient. Characteristic curves of 2^{nd} order equations. **Marks: 20**
Unit-IV: Laplace's equation: Elementary solution of Laplace's equation, Solutions in various coordinate systems. Greens function for Laplace's equation. The wave equation: the first Cauchy problem, the Mixed type problems, General solutions of the wave equation. Green's function for the wave equation. The diffusion equation: Solutions in various coordinate systems, Similarity solutions. **Marks: 20**

Reference Books:
1.Advanched differential Equations: M. D. Raisinghania
2.Ordinary differential Equations: M. D. Raisinghania
3.Elements of partial differential equations: Ian N Snedden, McGraw Hill.
4.Theory and problems of differential equations: Frank AyresJr. Schaum's Outline Series. McGraw Hill.

Paper Code: MAT 103
Paper Title: Mechanics
Theory Marks: 80
Internal Marks: 20

Unit-I: Variational principle and Lagranges Equations: Hamilton's principle, some techniques of the calculus of variations. Derivation of Lagrange's Equations from Hamilton's Principle. **Marks: 20**

Unit-II: Generalised coordinates, Halonomic & Non-holonimic systems, Scleronomic and Rheonomic systems, Generalized potential, Lagranges Equations of first kind and second kind, uniqueness of solution. **Marks: 20**

Unit-III: Canonical transformations: Introduction, Lagendre transformations, generating function and canonical transformations. Conditions for a transformation to be canonical. Illustrations of canonical transformations. Poisson's brackets & Lagrange brackets their properties. Applications of Poisson's brackets to Mechanics. **Marks: 20**

Unit-IV: Hamilton-Jacobi Equation, Hamilton-Jacobi Equation for Hamilton's characteristic function, Separation of variables in the Hamilton-Jacobi equation, problems and examples of the Hamilton-Jacobi method. **Marks: 20**

Reference Books:

1. Introduction to Classical Mecanics : R..Takwale & P.S. Puranik Tata Mc Graw Hill, 1983
2. Classical Mechanics : By H.Goldstein, Second edition, Narosa Publishing House, New Delhi.
3. Classical Mechanics : By N.C.Rana & P.S.Joag, Tata Mc Graw Hill,1991.
4. A.S.Ramsey Dynamics Part-II, the English Language Book Society and Cambridge University Press.

Paper Code: MAT 104
Paper Title: Real Analysis
Theory Marks: 80
Internal Marks: 20

Unit-I: Elements of set theory, finite and infinite sets, cardinal numbers, countable and uncountable sets, Axiom of choice, Real number system.

Unit-II: Sequences and series of functions, point wise and uniform convergence, Cauchy criterion for uniform convergence, relation of uniform convergence with continuity, differentiation and integration, Weierstrass approximation theorem. Fourier Series, Dirichlet criterion for convergence of Fourier series and its application into even and odd functions, function in any interval [a, b].

Unit-III: Functions of several variables, differentiation, implicit function theorem, inverse function theorem, maxima and minima.

Unit-IV: Functions of Bounded Variation and their properties, Differentiation of a function of bounded variation, Absolutely Continuous Function, Representation of an absolutely continuous function by an integral. Riemann-Stieltjes integrals, properties, mean value theorems, the fundamental theorem of Calculus.

Unit-V: Metric spaces, convergence, continuity, compactness, connectedness, completeness, Heine-Borel theorem, Intermediate value theorem, Baire Category theorem.

Reference Books:

1. Apostol, T. M., Mathematical Analysis, Narosa Publishing House, 1985.
2. Rudin, W., Principles of Mathematical Analysis, McGraw Hill, 1982.
3. Goldberg, R. R, Methods of real analysis, Oxford & IBH, 1970.
4. Simmons, G. F., Introduction to Topology and Modern Analysis, Tata McGraw Hill Book Co. Ltd., 1963.
5. Mallik, S. C. and Arora S. Mathematical Analysis, New Age International (P) Limited, New Delhi, 1992

Paper Code: MAT 105
Paper Title: Tensor Analysis
Theory Marks: 80
Internal Marks: 20

Unit I: **Marks: 20**

Curvilinear coordinates; Transformation of coordinates; Summation Convention; Dummy Suffix; Real Suffix; Covariant and Contravariant vectors; Tensors of Second Order; Mixed Tensors; Kronecker Delta; Algebra of Tensors; Symmetric and Skew-Symmetric tensors; Outer multiplication, Contraction and Inner Multiplication, Quotient Law of Tensors, Reciprocal Symmetric Tensor; Relative Tensor; Fundamental Tensor; Group property of tensors; Tensor Field.

Unit II: **Marks: 20**

Christoffel's symbols; Transformation of Christoffel's symbols; Differential equation of a Geodesic; Covariant differentiation of vectors; Covariant differentiation of tensors; Intrinsic derivative of a tensor; Laws of covariant differentiation of tensors; Divergence of a vector; Curl of a vector; Laplacian operator; Parallel displacement of a vector.

Unit III: **Marks: 20**

The metric tensor; Riemannian metric; Riemannian space; Geodesic coordinates; Natural coordinates; Riemannian Christoffel's tensor; Curvature of a curve; First curvature; Covariant curvature tensor; Properties of covariant curvature tensor; Bianchi Identity; Flat space time.

Unit 4: **Marks: 20**

Parallelism of vector of constant magnitude; Parallelism for vector of variable magnitude along a curve; Tensor differentiation; Laws of tensor differentiation; Weyl tensor.

Reference Books:

1. Tensor Calculus and Riemannian Geometry: D. C. Agarwal.
2. An Introduction to Riemannian Geometry and Tensor Calculus: Cambridge University Press: C. E. Weatherburn (1950).
3. Tensor Analysis : De Gruyter : Heinz Schade**,** Klaus Neemann**,** Andrea Dziubek**,** Edmond Rusjan (2018).

Paper Code: MAT 106 (Open Elective)
Paper Title: Fundamental of Mathematics
Theory Marks: 50

Unit I: Number System, Properties of Real Numbers, Sequences and Series, Infinite sequences and series: Formal definition of convergence, basic properties of convergent sequences and series.

Unit II: Sets and Their Properties, Cardinality, countable, and uncountable sets, More about relation and functions, injective, surjective, bijective properties, compositions and inverses

Unit III: Data collection, types of data and its classification of data by type, organize data into tables, and summarize data graphically, Normal Approximation for Data, central tendency, Mean, Median, Mode, Standard deviation, Histograms, Pie-chart

Unit IV: Sampling, Sample Surveys, Chance Errors in Sampling, Accuracy of Percentages, Accuracy of Averages. summarizing bivariate data - regression and correlation

Reference Books:

1. D. Freedman, R. Pisani, R. Purves, *Statistics*, 4th edition. W. W. Norton & Company (2007). ISBN: 978-0393-92972-0.
2. Mallik, S. C. and Arora S. Mathematical Analysis, New Age International (P) Limited, New Delhi, 1992

Paper Code: MAT 106 (Open Elective)
Paper Title: History of Mathematics
Theory Marks: 50

Unit I: Egypt and Babylon - Greek mathematics (Euclid, Archimedes, Apollonius, Ptolemy).
Unit II: Mathematics in the Islamic World - The transmission of the mathematics of antiquity to medieval Europe - Algebra, trigonometry and arithmetic in the Renaissance - Analytic geometry in the seventeenth century (Descartes, Fermat)
Unit III: The beginnings of calculus - The calculus of Newton and Leibniz - Newton's Principia - Euler - Gauss
Unit IV: Geometry in the oulvasatras, the origins of zero (which can be traced to ideas of lopa in Paoini's grammar), a cross-cultural view of the development of negative numbers (from Brahmagupta (c. 628 CE) to John Wallis (1685 CE).

Recommended Texts:
The course reader is Fauvel & Gray, History of Mathematics, a Reader (McMillan, C. £25), which is essential. Short surveys like D J Struik's Concise History (4th edn only) indicate a framework. General histories like those of Boyer & Merzbach, and V. Katz, are useful adjuncts to the course. S. Hollingdale's Makers of Mathematics is a readable and informative introduction.

Reference Books:
1. A short course in the History of Mathematics : W.W.Rouse Ball.
2. A History of Mathematics : Carl B.Boyer.
3. A History of Mathematics : Florian Cajori.
4. The History of Mathematics: A Very Short Introduction**:** Jacqueline Stedall
5. Studies in the History of Indian Mathematics (Culture and History of Indian Mathematics): C. S. Seshadri.

SEMESTER: - II

Paper Code: MAT 201
Paper Title: Complex Analysis
Theory Marks: 80
Internal Marks: 20

Unit -I: Analytic Function, Cauchy Riemann Equations, Harmonic Functions.

Unit -II: Cauchy's Integral formula, Cauchy's inequality, Poison's formula, Liouville's Theorem, Maximum Modulus Theorem, Zeroes and Poles of complex valued function, Rouche's Theorem, Fundamental Theorem of Algebra, The Argument Principle.

Unit-III: Taylor's and Laurant's Series, Classification of Singularities, Residues at a Pole, Calculation of Residues, Cauchy Residue Theorem, Jordan's Inequality.

Unit-IV: Application of Residue Theorem in Evaluation of Improper real Integrals, Conformal mappings and Bilinear transformations.

Reference Books:
1. Murray R. Spiegel, Seymour Lipschutz, John J. Schiller,Dennis Spellman, Complex Variables and Its Applications, 2nd Edition (Schaum's Outline Series. McGraw-Hill Publishing Company, New Delhi, 2008).
2. Conway, J. B. Functions of One Complex Variable, 2nd Edition (Narosa Publishing House, India, 1994).
3. Ahlfors, L. V. Complex Analysis, 3rd Edition (McGraw-Hill Publishing Company, New Delhi, 1979).
4. Priestly, H.A. Introduction to Complex Analysis, 2nd Edition (Cambridge, 2008).

Paper Code: MAT 202
Paper Title: Continuum Mechanics
Theory Marks: 80
Internal Marks: 20

Unit I: **Marks: 20**

Analysis of Stress: Body force and Surface forces, Cauchy's Stress Principle, State of Stress at a point, Equations of equilibrium, Stress Transformation Laws, Stress Quadric of Cauchy, Principal Stresses, Stress Invariants, Plane Stress, Deviator and Spherical Stress Tensors.

Unit II: **Marks: 20**

Analysis of Strain: Continuum Configuration, Lagrangian and Eulerian descriptions, Deformation Gradient and Displacement Gradients, Stretch Tensor, Rotation Tensor, Linear Strain Tensor, Principal Strains, Strain Invariants, Spherical and Deviator Strain Components, Equations of compatibility.

Unit III: **Marks: 20**

Material Derivatives, Path Lines and Stream Lines, Rate of Deformation and Vorticity with their physical interpretations, Natural Strain, Material Derivatives of Volume, Surface and Line (Elements and Integrals), Fundamental Laws of Continuum Mechanics.

Unit IV: **Marks: 20**

Elasticity, Hook's Law, Stress Energy Function, Elastic Symmetry, Fluid Pressure, Barotropic Flow, Constitutive Equation, Stokesian Fluids, Newtonian Fluids.

Reference Books:

1. Continuum Mechanics: G.E. Mase, Schaum's outline series, Mc Graw Hill.
2. Mathematical Theory of Continuum Mechanics: R. Chatterjee, Narosa Publishing, New-Delhi
3. Principles of Continuum Mechanics: J. N. Reddy, Cambridge University Press.

Paper Code: MAT 203
Paper Title: Functional Analysis
Theory Marks: 80
Internal Marks: 20

Unit I: Normed linear space, Banach spaces, *lp* spaces, *Lp* spaces, Quotient space, Function spaces of normed linear spaces, Convergence and completeness. Riesz lemma, basic properties of finite dimensional normed linear spaces and compactness, Bounded linear functional on Banach spaces. **Marks 20 (Contact Hours 12)**

Unit-II: Equivalent norms, Continuous linear transformations between normed linear spaces, Hahn-Banach theorem and its consequences, Normed linear spaces of bounded linear transformations, Dual spaces, Conjugate of an operator, Uniform boundedness theorem and some of its consequences, Closed range theorem. **Marks 20 (Contact Hours 12)**

Unit-III: Inner product spaces: inner product; Gram-Schmidt orthogonalization process, linear functionals and adjoints, self-adjoint, normal and unitary operators, orthogonal projections, spectral theorem for normal operators on a finite dimensional vector space. Bilinear forms: bilinear, positive and quadratic forms. **Marks 20 (Contact Hours 12)**

Unit-IV: Hilbert spaces, polarization identity and parallelogram law; orthogonality. Orthonormal systems. Fourier expansion and relation to orthonormal basis, Bessel's inequality. Parsevai's identity. Structure of Hilbert spaces. Projection theorem. Riesz representation theorem. Adjoint of an operator on a Hilbert space. Reflexitivity of Hilbert spaces. **Marks 20 (Contact Hours 12)**

Text Books:

1. Kreyszig E., Introductory Functional Analysis with Applications (John Wiley and Sons, New York, 1978).
2. Lipschutz S., Lipson M., Schaum's Outline of Linear algebra, Mc Graw Hill, Third edition

Reference Books:

1. Limaye, B. V. Functional Analysis (Wiley Eastern Ltd., New Delhi, 1989).
2. Rudin, W. Functional Analysis (McGraw Hill, 2000).
3. Halmos, P. R., Linear Algebra Problem Book, The Mathematical Association of America (MAA), USA, 1995.
4. Halmos, P. R., Finite dimensional vector spaces, Springer Verlag, New York, 1987.
5. Simmons, G. F. Introduction to Topology and Modern Analysis (Tata McGraw Hill Book Co. Ltd.,1963).

Paper Code: MAT 204
Paper Title: General Topology
Theory Marks: 80
Internal Marks: 20

Unit-I: Topological spaces, base and sub-base, subspaces. Closure, interior and boundary of a subset: their properties. Neighborhood structures. Characterisation of topology in terms of closure and interior operator. Continuity, open and closed functions, homeomorphisms, strong and weak topologies. Quotient and product spaces (finite product).
Unit-II: Countability axioms, separability, Lindelof spaces. Separation axioms (T0, T1, T2, T3, T4), regularity, complete regularity, normality, Urysohn's Lemma (Statement only) and its applications.
Unit-III: Compactness, local compactness, compactification, The Stone-ˇCech compactification. Alexandroff one point compactification, Connectedness, components, local and path connectedness.
Unit-IV: Tychonoff product (Product topology on arbitrary product), Separation axioms and product spaces, Compactness and product spaces, Connectedness and product spaces.

Reference Books:
1. Joshi, K. D.**,** Topology, Wiley-Eastern, 1988.
2. Willard, S. General Topology, Addision-Wesley, Reading, 1970
3. Munkres, J. R.**,** Topology : A first course (2/e), Prentice-Hall, 2000
4. Dugundji, J., Topology, Allyn and Bacon, 1966
5. Steen, L., Seebach, J., Counter Examples in Topology, Holt, Reinhart and Winston, New York, 1970

Paper Code: MAT 205
Paper Title: Mathematical Methods
Theory Marks: 80
Internal Marks: 20

Unit-I: Linear Integral Equations: Linear integral equation of the first and second kind of Fredholm and Volterra type, Solutions with separable kernels. Characteristic numbers and eigenfunctions, resolvent kernel. **Marks:20**
Unit-II: Laplace Transform: Basic properties of Laplace transform convolution theorem and properties of convolution, inverse Laplace transform, application of Laplace transforms to solution of ordinary and partial differential equations of initial and boundary value problems. **Marks:20**
Unit-III: Fourier Transform: Fourier integral transform properties of Fourier transform; Fourier sine and cosine transform application of Fourier transform to ordinary and partial differential equations initial and boundary value problems evaluation of definite integral. **Marks:20**
Unit-IV: Calculus of Variations: Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations. **Marks:20**

Reference Books:
1.Advanched Differential equations –M. D. Raisinghaniya
2.Calculus of variation with application : A. S. Gupta.
3. Theory and Problems of Laplace Transform: M. R. Spiegel.

Paper Code: MAT 206
Paper Title: Applications of Mathematics in Real life
Theory Marks: 50

Unit-I: Applications of Arithmetic Progression, Geometric Progression, Permutation and Combination.
Unit-II: Application of Straight Lines and Matrices: Solving Problems Relating to Business and Economics.
Unit-III: Applications of Simple Interest, Compound Interest and Annuity.
Unit-IV: Applications of Linear Programming: Mathematical Formulation of LPP, Solutions of LPP by Graphical Method.

Reference Books:

1. P. Hazarika, A Text Book of Business Mathematics, S. Chand
2. E. Don, J. Lerner, Basic Business Mathematics, Schaum's Outline

Paper Code: MAT 206
Paper Title: Mathematics Education
Theory Marks: 50

Unit I: Nature, Philosophy and Foundation of Mathematics; Principals of Mathematics; Philosophy of Mathematics and Mathematics Education, History and culture of Mathematics.

Unit II: Mathematics Education in Social and Political context; Mathematics as an intellectual property vs Mathematics as a humanistic discipline; History of Mathematics in and for the curriculum; Mathematics and symbolization.

Unit III: Structuration in Mathematics; Nature of mathematical ideas, Kinds of Mathematical statement, Mathematical Statements and proofs, Relation of Mathematics to logic, mathematical concepts and conceptual diversity.

Unit IV: Gender stereotypes in Mathematics; Mathematics for future vs Mathematics for appreciation; Principles and Standards for school Mathematics; Mathematics literacy and Mathematics for all.

Reference Books:

1. The Foundations of Mathematics by Ian Stewart and David Tall, Oxford University Press (1977).
2. An Introduction to the History of Mathematics, Third Edition by Howard Eves, Publisher: Cengage Learning (1990)

SEMESTER: - III

Paper Code: MAT 301
Paper Title: Fuzzy Set Theory
Theory Marks: 80
Internal Marks: 20

Unit-I: Fuzzy sets - basic definitions, α-level sets, convex fuzzy sets, basic operations on fuzzy sets, types of fuzzy sets, Cartesian products, algebraic products, bounded sum and difference, t-norms and t-conforms. Fuzzy sets in contrast of probability theory.

Unit-II: Possibility Theory; Fuzzy Measures, Evidence Theory, Necessity Measures, Probability Measures, Possibility Distribution, Possibility Theory and Fuzzy Sets.

Unit-III: The extension principle - the Zadeh's extension principle, image and inverse image of fuzzy Sets, fuzzy numbers, elements of fuzzy arithmetic.

Unit-IV: Fuzzy relations and fuzzy graphs, composition of fuzzy relations, min-max composition and its properties, fuzzy equivalence relations, fuzzy relation equations, fuzzy graphs.

Reference Books:

1. Zimmermann, H. J., Fuzzy set theory and its Applications, Allied publishers Ltd., New Delhi, 1991.
2. Klir, G. J. and Yuan, B., Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India, New Delhi, 1997.

Paper Code: MAT 302
Paper Title: Graph Theory
Theory Marks: 80
Internal Mark: 20

Unit I: Elementary Concepts of Graphs and Digraphs: Vertex degree and degree sequence; Subgraph; Graph isomorphism; Regular and complete graph; Bipartite and *k*-partite graph; Intersection Graph, line graph and block graph; Walk, trail, path, cycle and length. Basic of digraph; Oriented digraph; Out degree and in degree; Adjacency matrix of a labelled graph; Weighted graph **Marks: 20**

Unit II: Tree and Connectivity: Basic properties of trees; Distance in trees; Spanning tree; Enumeration of trees, Cayley's formula; Shortest path; Cut vertex, cut edge and blocks; Point-connectivity (connectivity) and line-connectivity; Menger's theorem; Connectivity of digraph **Marks:20**

Unit III: Traversability and Covering: Euler tour and Eulerian graph; The Chinese postman problem; Hamilton cycle and Hamiltonian graph; Travelling salesman problem; Covers and independent sets; Gallai and König theorems; Critcal points and lines. **Marks: 20**

Unit IV: Factorization and Planarity: *n*-factor, 1-factorization and 2-factorization; Tutte's 1-factor theorem; Petersen's theorem; *f*-factors; Graph embeddings; Planar graph; Euler's formula; Kuratowski's theorem; Parameters of planarity. **Marks: 20**

References:

1. Graph Theory, *F. Harary*, Narosha Publishing Co (Reprint 1998).
2. Introduction to Graph Theory, *D. B. West*, Prentice-Hall, (2001).
3. Basic Graph Theory, *K. R.* Parthasarathy, Tata McGraw Hill, (1994) .
4. Graph Theory with Applications, *J. A.* Bondy & *U. S. R.* Murty, North-Holland (1976).
5. Graph Theory and Complex Networks: An Introduction, Maarten van Steen, (2010).

Paper Code: MAT 303
Paper Title: Number Theory
Theory Marks: 80
Internal Marks: 20

Unit-I: Divisibility, greatest common divisor, least common multiple, Euclidean Algorithm. Chinese Remainder Theorem. Prime numbers, factorization in prime numbers, fundamental theorem of arithmetic. **Marks: 20**

Unit-II: Divisor functions, perfect numbers, Mersenne numbers, Fermat numbers. **Marks: 20**

Unit-III: Greatest integer function (Gauss function), Mobius function, Euler function. Congruences and its elementary properties, congruences in one unknown, complete residue reduced residue system. **Marks: 20**

Unit-IV: Diophantine equations, linear Diophantine equations, Pythagoras equation, sum of two squares. Quadratic residues and congruences of second degree in one unknown, Legendre symbol, Jacobi symbol, Congruences of second degree with prime modulus and with composite modulus. **Marks: 20**

Reference Books:

1. Burton, D. M. Elementary Number Theory, 6th Edition (Tata McGraw-Hill, New Delhi,2007).
2. Niven, I. and Zuckerman, H. An Introduction to the Theory of Numbers, 5th Edition (Wiley Eastern, New Delhi, 2000).
3. Hardy, G.H. and Wright, E. M. An Introduction to the Theory of Numbers, 4th Edition(Oxford University Press, 1960).
4. Andrews, G.E. Number Theory (Hindustan Publishing Corporation, New Delhi, 1992).

Paper Code: MAT 304
Paper Title: Numerical Analysis
Theory Marks: 80
Internal Marks: 20

Unit I: Direct method for solving of linear equations (Gauss elimination, Crout's method, LU decomposition, Cholesky decomposition) **Marks:** 20

Unit II: Iterative methods (Jacobi, gauss-Siedel, Relaxation method). Jordan's method, Escalator method Steepest descent and conjugate gradient method. **Marks:** 20

Unit III: Algebraic Eigen value problem: Properties of Eigen values and Eigen vectors, Power method, Inverse power method, Jacobi's method **Marks:** 20

Unit IV: Given's method. Orthogonal factorization, QR algorithm for Eigen value problem Eigen values of complex matrix and complex Eigen vectors. **Marks:** 20

Contact Hours Unit I -12 hours, Unit II -12 hours, Unit III -12 hours, Unit IV -12 hours,

Reference Books:

1. An introduction to Numerical Analysis: Kendal E. Atkinson, Johan Wiley and sons, Inc.
2. Numerical Methods in engineering & Science by Dr. B. S. Grewal
3. C.E. Froberg: Introduction to Numerical analysis, Addision Wesley publishing Company, sixth edition, 1981.
4. 3. S. S. Sastri: Introductory Methods of Numerical Analysis, Prentice Hall of India, New Delhi, 1997.
5. E. V. Krishnamurthy and S. K. Sen: Computer Based numerical Algorithms, East-West press Pvt. Ltd. 1976.

Paper Code: MAT 305
Paper Title: Special Theory of Relativity
Theory Marks: 80
Internal Marks: 20

Unit-I: Inertial and non –inertial frames, geometry of Newtonian mechanics, Galilean Transformations, Background of the fundamental postulates of the special theory of relativity, Lorentz transformation, relativistic concept of space and time and relativity of motion, geometrical interpretation of Lorentz transformation as a rotation. Lorentz transformation as a group. Relativistic addition law of velocities, Simultaneity of events, proper length and proper time, application in problems. Transformation of acceleration. **Marks:** 20

Unit-II: Relativistic mechanics, Variation of mass with velocity, transformation of mass, force and density. Equivalence of mass and energy. Transformation of momentum and energy, energy momentum vector. Application in problems. Relativistic Lagrangian and Hamiltonian. **Marks:** 20

Unit-III: Minkowski's space, geometrical representation of simultaneity, contraction and dilation, space like and time –like intervals, position four vectors, four velocity, four forces and four momentum, relativistic equations of motion. Covariant four-dimensional formulations of laws of mechanics. **Marks:** 20

Unit-IV: Electrodynamics: Fundamental of electrodynamics, transformation of differential operators, D'Alembert operator, derivative of Maxwell's equation, electromagnetic potentials and force Lorentz condition, transformations of charge and current density, invariance of Maxwell's equations, transformation equations of electric field strength and magnetic field induction components. **Marks:** 20

Reference Books:

1. Introduction to Special Relativity, Wiley Eastern Ltd. (1990) Robert.
2. The Mathematical Theory of Relativity, Cambridge University Press 1965 A S eddington.

Paper Code: MAT 306
Paper Title: Dissertation
External Marks: 80
Internal Marks: 20

Semester-IV

Paper Code: MAT 401
Paper Title: Advanced Topology
Theory Marks: 80
Internal Marks: 20

Unit-I: Nets and filters, convergenge in terms of nets and filters, ultrafilters and compactness. Theories of metrization, Urysohn's Lemma, Tietze Extension theorem, Urysohn metrization Theorem. Paracompactness, characterisation in regular spaces, metrization based on paracompactness,Nagata-Smirnov theorem, Stone's theorem, Smirnov's metrization theorem. **Marks: 20**

Unit-II: Uniformities, uniform continuity, product uniformities, metrisation, completeness and Compactness, completion. Proximity Structure: Smirnov Compactification **Marks: 20**

Unit-III: Topological groups, subgroups, quotient groups, homogeneous spaces, product groups. Homotopy and the fundamental group, computation of the fundamental group of the circle. **Marks: 20**

Unit-IV: Uniform structures in Topological groups, complete groups, completion of topological groups. Function spaces, pointwise convergence, uniform convergence, compact-open topology, k-spaces, equicontiniuty, Ascoli theorem **Marks: 20**

Reference Books:

1. Joshi, K. D. Topology, Wiley-Eastern, 1988.
2. Kelley, J. L. Topology, Van-Nostrand, 1955.
3. Munkres, J. R., Topology: A first course, Prentice-Hall, 1983.
4. Willard, S. General Topology, Addision-Wesley, Reading, 1970.
5. Engelking, R., General Topology, Polish Scientific Publishers, Warshaw, 1977.
6. Bourbaki, N. Elements of Mathematics: General Topology, Vols. I & II, Springer-Verlag, 1988.
7. Naimpally, S. A. and Warrack, B. D., Proximity Space, Cambridge Tracts in Mathematics and Mathematical Physics, No. 59, Cambridge University Press, 1969.

Paper Code: MAT 401
Paper Title: Fluid Dynamics
Theory Marks: 80
Internal Marks: 20

Unit I: **Marks:20**

Real fluids and Ideal fluids; Velocity and Acceleration of a fluid particle; Equation of continuity; Boundary Surface; Stream lines, Path lines and streak lines; Velocity potential; Irrotational and rotational motions; Vortex lines; Equation of motion: Langrange's and Euler's equations of motion; Bernoulli's Theorem.

Unit II: **Marks:20**

Motion in two-dimensions; Complex velocity potential; Sources, sinks, doublets and their images; Conformal mapping; Milne-Thomson circle theorem; Two-dimensional irrotational motion produced by motion of circular, co-axial and elliptic cylinders in an infinite mass of liquid; Theorem of Blasius; Stoke's stream function.

Unit III: **Marks:20**

Vortex motion and its elementary properties; Motions due to circular and rectilinear vertices; Kirchhoff vortex theorem; Stress components in a real fluid; Relations between rectangular components of stress. Connection between stresses and gradients of velocity; Navier-Stoke's equations of motion; Plane Poiseuille and Couette flows between two parallel plates; Flow through tubes of uniform cross section in form of circle and cylinder under constant pressure gradient.

Unit IV: **Marks:20**

Dynamical similarity; Buckingham Pi-theorem; Reynold's number; Maxwell's electromagnetic field equation; Magnetic Reynold's number; Wave motion; Stationary waves; Wave propagation in a canal of uniform depth, Progressive wave in deep water. Group velocity.

Reference Books:

1. Chorlton, Text Book of Fluid Dynamics, CBS Publishers, Delhi,1985.
2. G.K.Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994,
3. H.Schlichting, Boundary Layer Theory, McGraw Hill Book Company, New York, 1971.
4. M.D.Raisinghania, Fluid Mechanics (With Hydrodynamics) S.Chand and Company Ltd., New Delhi.
5. R.K.Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.

Paper Code: MAT 401
Paper Title: Operator Theory
Theory Marks: 80
Internal Marks: 20

Unit I: Banach Algebras: The Banach Algebra of Continuous Functions, Abstract Banach Algebras, Abstract Index in a Banach Algebra, The Space of Multiplicative Linear Functions, The Gelfand Transform, The Gelfand-Mazur Theorem, The Gelfand Theorem for Commutative Banach Algebras, The Spectral Radius Formula, The Stone-Weierstrass Theorem and consequences. **(Contact Hours 12)Marks 20**

Unit II: Operators on Hilbert Space and C*-Algebras: The Adjoint Operator, Normal and Self-adjoint Operators, Projections and Subspaces, Multiplication Operators and Maximal Abelian Algebras, C*-Algebras, The Spectral, The Functional Calculus, The Square Root of Positive Operators, Weak and Strong Operator Topologies, *-Homomorphisms of C*-Algebras. **(Contact Hours 12)Marks 20**

Unit III: Compact Operators, Fredholm Operators, Compact Operators : Approximation of Compact Operators, Examples of Compact Operators: Integral Operators, Fredholm Integral Operators, Volterra Integral Operators , Representations of the C*-Algebra of Compact Operators. **(Contact Hours 12)Marks 20**

Unit-IV: Unbounded Operators: Introduction, Unbounded Linear Operators in Hilbert Space, Unbounded Linear Operators and their Hilbert-Adjoint Operators, Hilbert-Adjoint Operators, Symmetric and Self-Adjoint, Linear Operators, Closed Linear Operators and Closures, Spectral Properties of Self-Adjoint Linear Operators, Spectral Representation of Unitary Operators, Self-Adjoint Linear Operators **(Contact Hours 12)Marks 20**

Reference Books:

1. Kreyszig E., Introductory Functional Analysis with Applications (John Wiley and Sons, New York, 1978).
2. Rudin, W. Functional Analysis (McGraw Hill, 2000).
3. Simmons, G. F. Introduction to Topology and Modern Analysis (Tata McGraw Hill Book Co. Ltd.,1963).
4. Limaye, B. V. Functional Analysis (Wiley Eastern Ltd., New Delhi, 1989).
5. Halmos, P. R., Linear Algebra Problem Book, The Mathematical Association of America (MAA), USA, 1995.
6. Halmos, P. R., Finite dimensional vector spaces, Springer Verlag, New York, 1987.
7. Lipschutz S., Lipson M., Schaum's Outline of Linear algebra, Mc Graw Hill, Third edition

Paper Code: MAT 402
Paper Title: Advanced Functional Analysis
Theory Marks: 80
Internal Marks: 20

Unit I: Topological Vector Spaces: Introduction, Separation properties, Linear mappings, Finite-dimensional spaces, Metrization, Boundedness and continuity, Seminorms and local convexity, Quotient space, completeness, convexity, Weak topologies, Compact convex sets **Marks 20 (Contact Hours 12)**

Unit II: Preliminaries on Banach Algebras and C* Algebras, Commutative Banach Algebras and Commutative C* Algebras, Representation of C* Algebras. **Marks 20 (Contact Hours 12)**

Unit III: Spectral Theory of linear operators in normed space, Spectral Properties of Bounded Linear Operators, Further Properties of Resolvent, Spectrum and Banach Algebras. Spectral Properties of Bounded Self-Adjoint Linear Operators, Positive Operators, Square Roots of a Positive Operator, Projection Operators, Spectral Family of a Bounded Self-Adjoint Linear, Spectral Representation of Bounded Self-Adjoint Linear Operators

Marks 20 (Contact Hours 12)

Unit-IV: Fixed Point Theorems and Some Applications to Analysis. **Marks 20 (Contact Hours 12)**

Text Books:

1. Kreyszig E., Introductory Functional Analysis with Applications (John Wiley and Sons, New York, 1978).
2. Rudin, W. Functional Analysis (McGraw Hill, 2000).
3. Simmons, G. F. Introduction to Topology and Modern Analysis (Tata McGraw Hill Book Co. Ltd.,1963).
4. Gerard J. Murphy, C* - Algebras and Operator Theory, Academic Press, Inc, 1990.
5. Ronald G. Douglas, Banach Algebra Techniques in Operator Theory, Second Edition, Springer-Verlag, New York, Inc, 1998.

Reference Books:

1. Limaye, B. V. Functional Analysis (Wiley Eastern Ltd., New Delhi, 1989).
2. Halmos, P. R., Linear Algebra Problem Book, The Mathematical Association of America (MAA),USA, 1995.
3. Halmos, P. R., Finite dimensional vector spaces, Springer Verlag, New York, 1987.
4. Lipschutz S., Lipson M., Schaum's Outline of Linear algebra, Mc Graw Hill, Third edition.

Paper Code: MAT 402
Paper Title: Dynamical Systems
Theory Marks: 80
Internal Marks: 20

Unit-I: Dynamical systems, discrete and continuous dynamical systems, Examples of dynamical systems. Iteration, Orbits, Types of Orbits, Other Orbits, The Doubling Function. **Marks:20**

Unit-II: Graphical Analysis, Orbit Analysis, The Phase Portrait, Fixed and Periodic Points, A Fixed Point Theorem, Attraction and Repulsion. **Marks:20**

Unit-III: Stability of a fixed point, equilibrium point, concept of limit cycle and torus, hyperbolicity, quadratic map period doubling phenomenon, feigenbaum's universal constant, Nonlinear oscillator, conservative system. Hamiltonian system. Various types of Oscillators in nonlinear system. Solution of nonlinear differential equations, Poincare map. **Marks:20**

Unit-IV: Bifurcations, The Quadratic Family, Transition to Chaos, Symbolic Dynamics, Chaos. Fractals, The Julia Set, The Mandelbrot Set. **Marks:20**

Reference Books:

1. Morris W. Hirsch, Stephen Smale: Differential Equation, Dynamical System and Linear Algebra, Academic Press.
2. D. K. Arrowsmith: An introduction to Dynamical systems
3. Robert L. Devaney: A First Course in Chaotic Dynamical Systems.

Paper Code: MAT 402
Paper Title: Category Theory
Theory Marks: 80
Internal Marks: 20

Unit I: Definition and examples of categories, The concept of functor and the category Cat. Natural Transformations, isomorphism, epimorphism, monomorphism, Mobics, Epis and Zeros Foundations, Large Categories, Hom-sets. Free Categories, Constructions of new categories from old categories, The Dual Category, The Arrow Category, The Slice and Co- Slice Category. **Marks: 20**

Unit-II: Epis and mono, Initial and Terminal objects, Generalized elements, Sections and Retractions, Categories of categories, properties of functors, natural transformation and natural isomorphism, isomorphisms and equivalences of categories, functor categories. **Marks: 20**

Unit-III: Groups in categories. The category of groups, Groups as categories, Congruence on a category, quotient category and its univalent mapping property, finitely presented categories. **Marks: 20**

Unit-IV: Equalizers and coequalizers, intersections and factorizations, products and coproducts, sources and sinks, limits and colimits, pullback and pushout, inverse and direct limits, complete categories, limits in factor categories. **Marks: 20**

Reference Books:

1. Awodey, S.: Category Theory, (Oxford Logic Guides, 49, Oxford University Press.)
2. Herrlich, Horst; Strecker, George E. (2007), Category Theory (3rd ed.), Heldermann Verlag Berlin

Paper Code: MAT 403
Paper Title: Fuzzy Logic and Fuzzy Control system
Theory Marks: 80
Internal Marks: 20

Unit-I: Fuzzy logic, fuzzy propositions, fuzzy quantifiers, linguistic variables, inference from conditional fuzzy propositions, compositional rule of inference.

Unit-II: Approximate reasoning - an overview of fuzzy expert systems, fuzzy implications and their selection, multi-conditional approximate reasoning, role of fuzzy relation equation.

Unit-III: An introduction to fuzzy control - fuzzy controllers, fuzzy rule base, fuzzy inference engine, fuzzification, defuzzification and the various defuzzification methods.

Unit-IV: Decision making in fuzzy environment - individual decision making, multi-person decision making, multi-criteria decision making, multistage decision making, fuzzy ranking methods, fuzzy linear programming, fuzzy logic as a tool in soft computing.

Reference Books:

1. Zimmermann, H. J., Fuzzy set theory and its Applications, Allied publishers Ltd., New Delhi, 1991.
2. Klir, G. J. and Yuan, B., Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India, New Delhi, 1997.

Paper Code: MAT 403
Paper Title: R**elativity and Cosmology**
Theory Marks: 80
Internal Marks: 20

Unit-I: Principle of Equivalence and Mach's, Covariance, Geodesic Principle, Newtonian approximation of Relativistic equations of motion, Einstein field equation and Newtonian approximation. Schwarzschild exterior solution and its isotopic form, planetary orbits, General Relativistic Kepler problem, Advance of Perihelion of a Planet, Bending of Light rays in a gravitational field, Gravitational Red shift in Spectral lines. **Marks:20**

Unit-II: Schwarzschild interior solution, Linearization of field equations, time-independent and spherically Symmetric field, The Weyl's solutions to the linearized field equations. Eddington's form of the Schwarzschild solution, Einstein's equations for Degenerate metrices, the Order m2 equations, Field equations for stationary case. **Marks: 20**

Unit-III: Einstein Field Equations with Cosmological term, static cosmological models of Einstein and De-sitter, their derivations, properties and comparison with the actual Universe. Cosmological principle, Hubble's law, Weyl's Postulate, Steady State Cosmological models, Derivation of Roberson -Walker Metric, Further Properties. **Marks: 20**

Unit-IV: Hubble and deceleration parameters, Red shift, mater dominated era of the Universe steady state cosmology, Friedman model. Fundamental Equation of dynamical Cosmology, Critical density, Closed and open universe, Age of the Universe. The Hot Big Bang and the Thermal History of the Universe, Early Universe and Inflationary Scenario, Mathematical Foundations. **Marks: 20**

Reference Books:

1. Gravitation and Cosmology: Principles and Applications of General Theory of Relativity - Steven Weinberg, John Wiley Publication.
2. General Relativity and Cosmology - J.V.Narlikar, Macmillan Company of India, 1978.
3. Mathematical Theory of Relativity - A.S.Eddington, Cambridge University Press, 1965.
4.Introduction to General Relativity - Ronald Ader, Maurice Bazin, Menahem, Schiffer.
5. Mathematical Theory of Relativity : A.S.Eddington, Cambridge University Press, 1965.
6. Relativity : The General Theory - J.L.Synge, North Holland Publishing Company, 1976.
7. The Classical Theory of Fields - I.D.Landau and E.M.Lifshitz, Pergamon Press, 1980.
8. An Introduction to Riemannian Geometry and the Tensor Calculus - C.E. Weatherburn, Cambridge University Press, 1950.

Paper Code: MAT 403
Paper Title: Operations Research
Theory Marks: 80
Internal Marks: 20

Unit I: Linear Programming Problem
Introduction- Operations Research and Decision Making, Mathematical Formulation of the Problem, Graphical Solution, Method, Simplex Method, Duality in Linear Programming. **Marks 20 (Contact Hours 12)**

Unit II: Queuing theory
General idea of queuing system- Poisson and Non-Poisson. Queuing theory and its operating characteristic queuing model –M/M/1, M/M/C, M/G/1. **Marks 15 (Contact Hours 9)**

Unit III: Games and Strategies:
Introduction- Two- person Zero-sum games-Pay-off Matrix – some basic terms-the Maxi-Min and Mini-Max Principle- Game Saddle Point and Value of the Game-Rule for determining a Saddle Point-Games without Saddle Points-Mixed Strategies-Graphic solution of 2 x n and m x 2 games- Dominance Property- General rule for Dominance-Modified Dominance Property. **Marks 20 (Contact Hours 12)**

Unit IV: Markov analysis:
Markov process, state transition matrix, steady state conditions, Markov algorithm, Special cases in Markov analysis. **Marks 15 (Contact Hours 9)**

Unit V: General Non-Linear Programming Problem (GNLPP), Kuhn-Tucker conditions for NLPP, Saddle Point Problem. **Marks 10 (Contact Hours 6)**

Text Book:

Operations Research by Kanti Swarup, P.K. Gupta and Man Mohan, Published by Sultan Chand & Sons, New Delhi-110002, Ninth Edition (2002).

Reference Books:

1. Operation Research – An Introduction by Hamdy A. Taha. Published by Prentice-Hall of India Pvt. Ltd., New Delhi- 110001, Sixth Edition (2002).
2. Kanti Swarup, P.K. Gupta and Manmohan : Opeartion Research, S.Chand and Co.
3. P. K. Gupta and D S Hira : Operations Research-An Introduction, S. Chand and Co

Paper Code: MAT 404
Paper Title: Advanced Graph Theory
Theory Marks: 80
Internal Mark: 20

Unit I: Matching and Domination: Basic concepts of matching; maximum, maximal and perfect matching; Augmented path; Berge's theorem; Matching in bipartite graph; König's theorem for maximum matching; Hall's theorem; *c*-matching; Dominating set and dominating number; Closed neighbourhood; Connected, independent and total dominating set. **Marks:20; Hours: 12**

Unit II: Colourability: Vertex and edge colouring; Chromatic number and edge chromatic number; Bounds for chromatic number; Brooks' theorem; Vizing's theorem; The four colour theorem; The five colour conjecture; Uniquely colourable graph; Critical graph; Chromatic polynomial. **Marks:20; Hours: 12**

Unit III: Application of Graph in Complex Networks: Introduction to complex networks; Network traversal; Construction of Euler tour; Finding a Hamilton cycle; Trees in transportation networks; Routing in communication networks; Random networks; Computer networks; Social networks analysis; Structural balance; Affiliation networks; Equivalence; Structural equivalence. **Marks: 20; Hours: 12**

Unit IV: Generalization of Graph:: Hypergraph & Semigraph: Introduction to Hypergraph; Dual of hypergraph; Cycles in hypergraph; conformal hypergraphs; Representative graph of a hypergraph; matching in hypergraph; Introduction to Semigraph; Degrees in semigraph; Subsemigraph and partial subsemigraph; *s*-Path and *s*-cycle; Edge bipartite semigraph; Dendroids. **Marks: 20; Hours: 12**

Reference Books:

1. Introduction to Graph Theory, *D. B. West*, Prentice-Hall, (2001).
2. Graphs and Hypergraphs, *C. Berge*, North-Holland, London (1973).
3. Graph Theory, *F. Harary*, Narosha Publishing Co (Reprint 1998).
4. Graph Theory and Complex Networks: An Introduction, Maarten van Steen, (2010).
5. Hypergraphs, *C. Berge*, North-Holland, London (1973).
6. Semigraph and Their Application, *E.* Sampathkumarachar, Academy of Discrete Mathematics and Applications, Lecture Notes, Series No. 1.
7. Basic Graph Theory, *K. R.* Parthasarathy, Tata McGraw Hill, (1994)

Paper Code: MAT 404
Paper Title: Advanced Numerical Analysis
Theory Marks: 80
Internal Mark: 20

Unit I: Numerical Solution of Ordinary Differential equations **Marks:** 20
Euler's method modified Euler's method, Runge's method, Runge-Kutta method, Predictor-corrector method, Milne's method, Adams-Bash forth method, Boundary-value problems, Finite-difference method.
Unit II: Numerical Solution of Partial Differential equations **Marks:** 20
Finite-Difference approximations to partial derivatives, Elliptic equations, Solution of Laplace equation, Solution of Poisson's equation,
Unit III: Solution of elliptic equations by relaxation method, parabolic equations, hyperbolic equations. **Marks:** 20
Unit IV: Approximation **Marks:** 20
Different types of approximation, least square polynomial approximation, polynomial approximation by use of orthogonal polynomials, approximation with Chebyshev polynomials.
Contact Hours Unit I -12 hours, Unit II -12 hours, Unit III -12 hours, Unit IV -12 hours,

References Books:

1. Numerical Methods in engineering & Science by Dr. B. S. Grewal
2. An introduction to Numerical Analysis: Kendal E. Atkinson, Johan Wiley and sons, Inc.
3. C.E. Froberg: Introduction to Numerical analysis, Addision Wesley publishing Company, sixth edition, 1981.
4. 3. S. S. Sastri: Introductory Methods of Numerical Analysis, Prentice Hall of India, New Delhi, 1997.
5. E. V. Krishnamurthy and S. K. Sen: Computer Based numerical Algorithms, East-West press Pvt. Ltd. 1976.

Paper Code: MAT 404
Paper Title: Advanced Number Theory
Theory Marks: 80
Internal Mark: 20

Unit-I: Arithmetical functions and Dirichlet multiplication, averages of arithmetical functions. Elementary theorems on the distribution of primes, the prime number theorem, Chebyshev's functions and their relations. Dirichlet's theorem for primes. **Marks: 20**
Unit-II: Quadratic residues and quadratic reciprocity law, applications of the reciprocity law, Gauss sums. **Marks: 20**
Unit-III: Dirichlet series, Euler products, Riemann zeta function and Dirichlet L-functions. **Marks: 20**
Unit-IV: Introduction to partitions, geometric representation, generating functions, Euler's Pentagonal number theorem, Jacobi triple product identity, Jacobi's identity, recursion formula for p(n). Ramanujan's partition identities. **Marks: 20**

Reference Books:

1. Apostol, T. M. Introduction to Analytic Number Theory, Springer International Student Edition (Narosa Publishing House, New Delhi, 1993).
2. Hardy, G.H. and Wright, E. M. An Introduction to the Theory of Numbers, 4th Edition (Oxford University Press, 1960).
3. Berndt, B.C., Number Theory in the spirit of Ramanujan.
4. Niven, I. and Zuckerman, H. An Introduction to the Theory of Numbers, 5th Edition (Wiley Eastern, New Delhi, 2000).
5. Andrews, G.E. Number Theory (Hindustan Publishing Corporation, New Delhi, 1992).

Paper Code: MAT 405
Paper Title: Dissertation
External Marks: 80
Internal Marks: 20
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