DEPARTMENT OF MATHEMATICS
T R I P U R A U N I V E R S I T Y

Integrated Master Degree(IMD)

in

MATHEMATICS

Syllabus

2014

PREAMBLE

From the academic session 2014-15, Tripura University is offering Mathematics as a option to be taken as a Major/Core subject. If Mathematics is opted as a Major subject by any candidate then he/she will have to study 8 papers of 100 marks each in the subject. Whereas if it is taken as an elective subject then the candidate have to study 5 papers of 100 marks each.

INTEGRATED MASTER DEGREE(IMD) in ***MATHEMATICS***

CONTENTS

Integrated Master Degree(IMD)
in
MATHEMATICS
Paper-I

Unit-I
(Classical Algebra & Number Theory)

1. Inequalities : A. M. ≥G.M ≥ H.M. Their generalization like the theorem of weighted mean and m^{th} power theorem. Statement of Cauchy-Schwartz inequality, Weierstrass inequality and their application. DeMoivre's theorem and its applications. Expotential sine, cosine and logarithm of complex number.
2. Direct and inverse circular and hyperbolic functions. Expansion of trigonometrical functions. Gregory's series. Summation of series. Statements of well ordering principle, first principle of mathematical induction, second principle of mathematical induction. Proofs of some simple mathematical results by induction. The division algorithm, The greatest common divisor (g.c.d.) of two integers a and b. Relatively prime integers.
3. The equation ax+ by = c has integral solution iff (a,b) divides c. (a , b, c are integers). Prime numbers. Euclid's first theorem: If some prime p divides ab, then p divides either a or b. Euclid's second theorem: There are infinitely many prime integers. Unique factorization theorem. Statement of Chinese Remainder Theorem and simple problems. Euler ϕ function.

Unit-II
(Abstract Algebra-I)

1. Set theory: Revision of set theory and algebra, relation and mapping. Order relations, equivalence relations and partitions. Congruence modulo n. Further theory of sets and mapping, Cardinality of sets, countable and uncountable sets, $\aleph_0$ and $\aleph_1$. Binary operation.
2. Group Theory: Semi-group, Definition, examples and simple properties of Group, Some special groups like Z_n, U(n), Dihedral groups, etc., Abelian group. Subgroup, the necessary and sufficient condition of a non-empty subset of a group is a subgroup, intersection and union of two subgroups.
3. Cyclic groups and its various properties. Order of a group and order of an element of a group, Permutation : Cycle, transposition, Statement of the result that every permutation can be expressed as a product of disjoint cycles. Even and odd permutations, Permutation Group. Symmetric group. Alternating Group. Order of an alternating group.

UNIT-III
(Abstract Algebra-II)

1. Group Homomorphism, Automorphism, Endomorphism and Isomorphism. Cosets and their various properties, index of a subgroup, Lagrange's theorem and its applications, Normal subgroups:Definition, examples and properties.
2. Rings and Fields: Properties of Rings directly following from the definition, Unitary and commutative rings. Divisors of zero, Integral domain, Every field is an integral domain, every finite integrals domain is a field.

3. Definitions of Sub-ring and sub-field. Necessary of sufficient condition for a subset of a ring (field) to be sub-ring (resp. subfield). Characteristic of ring and integral domain. Ring and field Homomorphism, Isomorphism. Quotient-ring.

Unit-IV
(Vector Algebra)

1 Vector Algebra: Vector (directed line segment) Equality of two free vectors. Addition of Vectors. Multiplication by a Scalar. Position vector, Point of division, Conditions of collinearity of three points and co-planarity of four points. Rectangular components of a vector in two and three dimensions. Product of two or more vectors. Scalar and vector products, scalar triple products and Vector triple products. Product of four vectors.

2. Direct application of Vector Algebra in (i) Geometrical and Trigonometrical problems (ii) Work done by a force, Moment of a force about a point.

3. Vector equations of straight lines and planes. Volume of a tetrahedron. Shortest distance between two skew lines.

Reference:

1. Advanced Higher Algebra: Ghosh and Chakraborty, U.N.Dhur.
2. Algebra: R.M.Khan, Central
3. Higher Algebra: Mapa, Ashok Pub.
4. Number Theory: S.B.Malik, New Age Pub.
5. Cordinate Geometry: S.B.Sengupta

Integrated Master Degree(IMD)
in
MATHEMATICS
Paper-II

Unit-I
(Linear Algebra-I)

1 Matrix: Matrices of real and complex numbers : Algebra of matrices. Symmetric and skew-symmetric matrices. Hermitian and skew-Hermitian matrices. Orthogonal matrices. Inverse of a Matrix, Solution of linear equation with not more than three unknown by matrix method. Rank of a matrix, Row rank, Column Rank, determination of rank either by considering minor or sweep out process. Row rank = column rank = Rank of the matrix, Rank (A+B)<RankA + RankB, Rank(AB)< Min(RankA, RankB)(statement only).

2. Characteristics polynomial & minimal polynomials, characteristics equations, Eigen value & Eigen Vector. Cayley Hamilton theorem(statement only), Simple properties of eigenvalues and eigenvectors.

3. Vector / Linear space : Definitions and examples, Subspace, Union and intersection of subspaces. Linear sum of two subspaces.

Unit II
(Linear Algebra-II)

1. Linear combination, independence and dependence. Linear span. Basis of vector space. Finite dimensional vector space. Replacement Theorem, Extension theorem, Statement of the result that any two bases of a finite dimensional vector space have same number of elements. Dimension of a vector space. Extraction of basis, formation of basis with special emphasis on R^n ($n \leq 4$).

2. Row space and column space of matrix. Row rank and column rank of matrix. Equality of row rank, column rank and rank of a matrix. Linear homogeneous system of equations : Solution space. For a homogeneous system AX = 0 in n unknowns, Rank X(A) + Rank A = n; AX = 0 contains non-trivial solution if Rank A < n. Necessary and sufficient condition for consistency of a linear non-homogeneous system of equations. Solution of system of equations (Matrix method).

3. Linear transformations and their representation as matrices. The algebra of linear transformations, rank and nullity theorem.

Reference:

1. Advanced Higher Algebra: Ghosh and Chakraborty, U. N, Dhur.
2. Algebra: R.M.Khan, Central
3. Higher Algebra: Mapa, Ashok Pub.

Unit-III
(Geometry-Two Dimension)

1 Transformation of rectangular axes, translation, rotation and their combinations, theory of invariants. General equation of second degree in two variables, reduction into canonical form, lengths and position of the axes.

2 Pair of straight lines: Condition that the general equation of second degree in two variables may represent a pair of straight lines. Point of intersection of two intersecting straight lines, angle between two lines given by $ax_2+2hxy+by_2$, equation of bisectors of the angle between the

pair of straight lines, equation of two lines joining the origin to the point in which two curves meet.

3 Polar coordinates, polar equation of straight lines, circles and conic referred to a focus as pole, equation of chord, tangent and normal.

Unit-IV
(Geometry-Three Dimension)

1 Rectangular Cartesian co-ordinates in space, concept of geometric vector (directed line segment), projection of vector on a co-ordinate axis, inclination of a vector with an axis, co-ordinates of a vector, direction ratio and direction cosine of a vector. Distance between two points, division of directed line segment in given ratio. Equation of a plane in general form, intercept and normal form, signed distance of a point from a plane, equation plane passing through the intersection of two planes, angle between two intersecting planes, parallel and perpendicularity of two planes.

2 Straight lines in space, equation in symmetric and parametric form, canonical equation of line of intersection of two intersecting planes, angle between two lines, distance of a point from a line, condition of coplanarity of two lines, shortest distance between two skew lines.

3 General equation of sphere , circle, sphere through the intersection of two sphere, radical plane, tangent, normal. General equation of cone and cylinder, right circular cone and cylinder.

References:

1. Co-ordinate Geometry-S.B.Sengupta.
2. Co-ordinate Geometry-S.L.Lony, Macmillan and Co.

Integrated Master Degree(IMD)
in
MATHEMATICS
Paper-III

UNIT I
(Calculus-I)

1. Limit and continuity of a real valued function at a point (the point must be a limit point of the domain set of the function). Algebra of limits. Sandwich rule. Continuity of composite functions.
Bounded functions. Neighbourhood properties of continuous functions regarding boundedness and maintenance of same sign. Continuous function on [a,b] is bounded and attains its bounds. Intermediate value theorem.
2. Discontinuity of function, type of discontinuity. Step function. Piecewise continuity. Monotone function. Monotone function can have only jump discontinuity. Set of points of discontinuity of a monotone function is at most countable. Definition of uniform continuity and examples. Lipschitz condition and uniform continuity. Functions continuous on a closed and bounded interval is uniformly continuous.
3. Infinite Series of real numbers: Convergence, Cauchy's criterion of convergence. Series of non-negative real numbers: Tests of convergence – Cauchy's condensation test. Comparison test (ordinary form and upper limit and lower limit criteria), Ratio Test , Root test, Raabe's test, Bertrand's test, Logarithmic test and Gauss's test. Alternating series, Leibnitz's test. Absolute and conditional convergent series. Rearrangement of series through examples.

Unit-II
(Calculus-II)

1. Definition of differentiability. Meaning of sign of derivative. Chain rule.
Successive differentiation : Leibnitz theorem and its applications. Statement of L' Hospital's rule and its applications. Darboux theorem, Rolle's theorem, Mean value theorems of Lagrange and Cauchy – as an application of Rolle's theorem.
2. Taylor's theorem on closed and bounded interval with Lagrange's and Cauchy's form of remainder deduced from Lagrange's and Cauchy's mean value theorem respectively. Maclaurin's theorem as a consequence of Taylor's theorem. Statement of Maclaurin's Theorem on infinite series expansion. Expansion of e^x, $\log(1+x)$, $(1+x)^m$, $\sin x$, $\cos x$ with their range of validity.
3. Functions of several variables: Limits and continuity (definition and examples only), Partial derivative. Total differentials. Statement of Schwartzs and Young's theorem on commutative property of mixed derivative. Euler's theorem of homogeneous functions of two variables. Statement of Taylor's theorem for functions of two variables.

Unit-III
(Calculus-III)

1**.** Point of local extremum (maximum, minimum) of a function in an interval. Sufficient condition for the existence of a local maximum/minimum of a function at a point (statement only). Determination of local extremum using first order derivative. Application of the principle of maximum/minimum in geometrical problems. Jacobian, maxima, minima, saddle points of functions of two variables (example only).

2. Tangent, normal, sub tangent and sub normal. Length of tangent and normal. Angle of intersection of curves. Pedal equation of a curve, pedal of a curve. Differential of arc lrngth. Curvature-Radius of curvature, centre of curvature, chord of curvature,
evolute of a curve. Rectilinear asymptotes for Cartesian and polar curves. Envelopes of families of straight lines and curves (Cartesian and parametric equations only).

3. Reduction formulae such as $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \tan^n x dx$, $\int \sec^n x dx$, $\int \sin^n x \cos^m x dx$, $\int \sin^n x \cos mx dx$ etc.

References:

1. Introduction to Real Analysis-Bertle & Sherbert-Wiley
2. Introduction to Analysis-Part I- Ghosh & Maity, Books and Allied (P) Ltd.
3. Introduction to Analysis-Part II- Ghosh & Maity, Books and Allied (P) Ltd.
4. Mathematical Analysis-Malik and Arora-New Age International Pub.

Unit-IV
(Vector Calculus)

1 Vector function, limit and continuity, derivative of vector, derivative of sums and product of vector functions. A necessary and sufficient condition that a proper vector â (i) has a constant length that â.dâ/dt = 0, (ii) always remains parallel is that â × dâ/dt=Õ.

2 Vector integration, scalar and vector fields, directional derivatives, gradient of a scalar point function, ∇ operator, divergence, curl and Laplacian.

3 Line, surface and volume integral. Gauss's, Stoke's theorem and problem based on these.

References:

Vector Analysis-Maity and Ghosh, New Central Book Agency.
Vector Analysis- Schaum's series, Tata McGrawHill

Integrated Master Degree(IMD)

in

MATHEMATICS

Paper-IV

Unit-II

(Differential Equations-I)

1. Significance of ordinary differential equation. Geometrical and physical consideration. Formation of differential equation by elimination of arbitrary constant. Meaning of the solution of ordinary differential equation. Concept of linear and non-linear differential equations. Equations of first order and first degree : Statement of existence theorem. Separable, Homogeneous and Exact equation. Condition of exactness, Integrating factor. Rules of finding integrating factor, (statement of relevant results only),Equations reducible to first order linear equations.

2. Equations of first order but not of first degree, Clairaut's equation. Singular solution, Applications : Geometric applications, Orthogonal trajectories. Higher order linear equations with constant co-efficients : Complementary function, Particular Integral, Symbolic operator D.

3. Method of undetermined co-efficients, Method of variation of parameters. Euler's homogeneous equation and Reduction to an equation of constant coefficients.

Unit-II

(Differential Equations-II)

1. Exact differential equations of higher order, method of solution, Non-linear exact equations, linear equations of some special forms,

2. Second order linear equations with variable co-efficients, Reduction of order when one solution the homogeneous part is known. Complete solution. Method of variation of parameters. 3. Reduction to Normal form. Change of independent variable. Operational Factors. Simple eigenvalue problems. Simultaneous linear differential equations.

References:

1. Differential Equations: Ghosh and Chakraborty, U.N.Dhur
2. Differential Equations: M.D.Raisinghania, S. Cand.
3. Advanced Differential Equations-M.D.Raisinghania-S.Chand.
4. Simplified course in differential equations-M.D.Raisinghania-S.Chand.

Unit-III

(Linear Programming Problem-I)

1 What is LPP ? Mathematical form of LPP formulation. LPP in matrix notation. Graphical solution of LPP. Basic solution, Basic feasible solution, degenerate and non-degenerate BFS.

2 Euclidean space, hyperplane, convex set, extreme points, convex functions and concave functions, the hyperplane in convex set. Intersection of two convex sets is convex set, the collection of all feasible solution of a LPP constitutes a convex set. A BFS to a LPP corresponds to an extreme point of convex set of feasible solutions.

3 Slack, surplus and artificial variables, standard form of LPP, Fundamental theorem pf LPP and their applications, theory and application of the simplex method of solution of LPP. Charne's M-technique.

Unit-IV
(Linear Programming Problem-II)

1 Degeneracy. The two phase method.
2 Duality theory. The dual of the dual is primal, relation between the objective function value of dual and primal problems. Relation between their optimal values. Statement of fundamental theorem of duality. Dual simplex method.
3 Transportation problem. TP in LPP form, Balanced TP. Optimality test of BFS. Assignment problem. Solution of AP [(Maximization, unbalanced, negative cost and impossible assignment. Traveling salesman problem.
(Problem should be set on simplex and Charne's method, two phase method in such ay that it may contain at most three or four tableau with approximate marks.)

References:

1. Linear Programming Problem- Chakroborty and Ghosh-U.N.Dhur and Sons
2. Operations Research-Kantiswarup et. al, Sultan Chand and Sons.
3. Linear Programming and Theory of Games, P.M.Karak, Central Book Agency.

Integrated Master Degree(IMD)
in
MATHEMATICS
Paper-V

Unit-I
(Numerical analysis-I)

1 Error in numerical analysis. Gross error, rounding off error, truncation error. Approximate numbers, significant figure. Absolute, relative and percentage error. General formula for error. Δ, ∇, E, δ, μ operators, their properties and interrelations. Equispaced arguments, differece table, propogation of error in difference table.

2 Interpolation: Statement of Weierstrass' approximation theorem, polynomial interpolation and error term in polynomial interpolation, deduction of Lagrange's interpolation formula, inverse interpolation, finding root of a equation by interpolation method. Deduction of Newton's forward and backward interpolation formula. Statement of Gauss's forward and backward interpolation formula. Starling's and Bessel's interpolation formulae. Error terms. Divided difference, Genaral interpolation formulae, deduction of Lagrange's, Newton's forward and backwards interpolation formula.

3 Numerical Differentiation based on Newtons's forward, Newton's backward and Lagrange interpolation formula. Error terms. Numerical integration: Integration of Newton's interpolation formula. Newton-Cotes formula. Deduction of Trapezoidal rule and simpson's 1/3 rule, statement of Weddle's rule. Statements of error terms.

Euler Maclaurin's sum formula.

Unit-II
(Numerical Analysis-II)

2.1 Numerical Solution of non-linear equations: Location of a real roots by tabular method, Bisection method, secant/Regula-Falsi, fixed point iteration and Newton-Raphson method, their geometric significance and convergency, order ofconvergence. Newtons method for multiple roots.

2.2 Numerical solution of a system of linear equations: Gause elimination , Gause-Jordan method. Pivoting strategy in Gauss elimination.LU-Decomposition. Inversion of 3×3 non-singular matrices by Gause elimination and Gause-Jordan method. Gause-Siedel iteration method for system of linear equation.

2.3 Numerical solution of ordinary differential equation of first order: Euler's method, modified euler's method, Picard's method, Taylor's series method, Runge-Kutta method, Milne's method.

Refernces:

1. Numerical Analysis-S.A.Mollah, New Central Book Agency.

Unit-III
(Probability)

1.1 Frequency and Axiomatic definition of probability. Random Variable, distribution function, discrete and continuous distribution. Binomial, Poisson, Beta, Gama, Uniform and normal distribution. Poisson process. Transformation of random variables.

1.2 Two dimensional probability distributions, discrete and continuous distribution in two dimensions, Uniform distribution and two dimensional normal distribution. Conditional distribution. Transformation of random variables in two dimensions.
1.3 Mathematical expectation, mean, variance, moment, central moments, measures of dispersion, skewness and curtosis, median, mode, quartiles. Moment generating function, characteristic function, statement of their uniqeness. Two dimensional expectation, covariance, correlation co-eficient, joint characteristic function, multiplication rule for expectation, conditional expectation.

Unit-IV
(Statistics)

3.1 Random sample, concept of sampling and various types of sampling, sample and population. Collection, tabulation and graphical representation, grouping of data, sample characteristic and their computation, sampling distribution of statistic.
3.2 Estimates of population characteristic or parameter, point estimation and interval estimation, criterion of a good point estimate, maximum likelihood estimate. Interval estimation of population proportion, interval estimation of a Normal population parameters, estimate of population parameters with large sample when distribution of the population is unknown.
3.3 Testing of Hypothesis:null hypothesis and alternative hypothesis. Type one and type two error, testing of hypothesis for a population proportion and Normal population parameters and large sample test for population with unknown distribution. Chi-square test of goodness of fit.

References:

1. Ground Work of Mathematical Probability and Statistics-Amritabha Gupta, Academic Pub.
2. Mathematical Statistics-Gupta and Kapur-Sultan Chand.

Integrated Master Degree(IMD)
in
MATHEMATICS
Paper-VI

Unit-I
(Analysis-I)

1. Bounded subset of R, L.U.B. (supremum) and G.L.B. (infimum) of a set. Least upper bound axiom. Characterization of R as a complete ordered field. Definition of an Archimedean ordered field. Archimedean property of R. Q is Archimedean ordered field but not ordered complete.
Neighbourhood of a point. Interior point. Open set. Union, intersection of open sets. Limit point and isolated point of a set. Bolzano-Weierstrass. Complement of open set and closed set. Dense set in R.
2. Covering and compactness, Heine Borel theorem. Sequences of real numbers : Bounded sequence. Convergence and divergence. Examples. Every convergent sequence is bounded and limit is unique.
3. Monotone sequences and their convergence. Sandwich rule. Nested interval theorem. Cauchy's first and second limit theorems. Subsequence. Subsequential limits. Lim sup upper (limit) and lim inf (lower limit) of a sequence using inequalities. Bolzano-Weierstrass theorem for sequence. Cauchy's general principle of convergence

Unit-II
(Analysis-II)

1 Riemann integration on [a,b] . Riemann approach Riemann sum and Riemann integrability. Darbaux's approach: upper sum U(P,f) and lower sum L(P,f), upper and lower integral, Darboux's theorem, necessary and sufficient condition of Riemann integrability. Equality of Riemann and Darboux's approach.
2 R-integrability of sum, product and quotient. R-integrability of $f \Rightarrow$ R-integrability of $|f|$. Integrability of monotone functions, continuous functions, piecewise continuous functions, function having (i) finite number of point of discontinuities, (ii) having finite number of limit points of discontinuities.
3 Function defined by the definite integral $\int_a^x f(t)dt$ and its properties. Primitives or indefinite integrals. First mean value theorem of integral calculus. Second mean value theorem of integral calculus (both Bonet's and Weierstrass's forms).

References:

1. Mathematical Analysis-W.Rudin- Tata McGrawHill.
2. Mathematical Analysis-Apostal- Narosa
3. Mathematical Analysis-Malik and Arora-New Age International Pub.
4. Introduction to Real Analysis-Bertle & Sherbert-Wiley.

Unit-III
(C Programming-I)

Algorithm and flowcharts with simple examples. Bracing and looping.

Introduction to ANSI-C : Character set in ANSI-C. Key words: int, char, float, while etc. Constant and Variables, expressions, assignment statements, formatting source files. Header files.Data types, declarations, different types of integers, different kinds of integer constants, floating-point types, initialization, mixing types, the void data type. Type defs. standard input/output. finding address of an object, Operations and expressions, precedence and associatively, unary plus and minus operators, binary arithmetic operators, arithmetic assignment operators, increment and decrement operators, comma operator, relational operators, logical operators.

Unit-IV
(C Programming-II)

Control flow, conditional and unconditional bracing, looping, nested loops. if-else, do-while, for, switch, break, continue, goto statements etc., Infinite loops. Functions. Arrays and Pointers

References:

1. Programming in ANSI-C-E.Balaguruswami, Tata McGrawHill.
2. Let Us C-Kanethkar-BPB Pub.

Integrated Master Degree(IMD)
in
MATHEMATICS
Paper-VII

Unit-I
(Analysis-III)

1. Improper integrals and their convergence, absolute and non-absolute convergence. Tests of convergence: Comparison test, m-test. Abel's and Dirichlet's test for convergence of integral of a product.
2. Beta and Gamma functions and their convergence, their properties and interrelation.
3. Geometric interpretation of definite integral. Fundamental theorem of integral, area enclosed by plane curves. Rectification of plane curves. Volume and surface area of solid formed by revolution of plane curves and areas about x-axis and y-axis.

Unit-II
(Analysis-IV)

1. Sequence and sequence of functions, pointwise and uniform convergence, boundness and continuity, integrability and differentiability of limit function in case of uniform convergence. Weierstrass M-test of uniform and absolute convergence. Power Series, radius of convergence using upper limit, uniform convergence of power series, properties, term by term integration and differentiation, uniqueness of power series.
2. Fourier series, Dirichlet's condition of convergence, Calculation of Fourier's coefficients, Fourier theorem, half range series, sine series, cosine series, Fourier series in arbitrary interval, Parseval's identity, basic theorems.
3. Evaluation of double and triple integrals, Dirichlet's integrals, change of order of integration in double integrals. Differentiability and integrability of an integral of a function of a parameter. Differentiation under the sign of integration

References:

1. Mathematical Analysis-W.Rudin- Tata McGreawHill.
2. Mathematical Analysis-Apostal- Narosa
3. Mathematical Analysis-Malik and Arora-New Age International Pub.
4. Introduction to Real Analysis-Bertle & Sherbert-Wiley.

Unit-III
(Tensor Analysis)

1 Summation Convension, Kronecker symbol. n-dimensional space, transformation of coordinates in S_n. Invariants, covariant and contravariant vectors. Covariant, contravariant and mixed tensors. Algebra of tensors. Symmetric and skew-symmetric tensors. Contraction, outer and inner product of tensors. Quotient law, reciprocal tensor. Riemann space, the line element and metric tensor, raising and lowering of indices, associate tensor, magnitude of a vector, inclination of two vectors, orthogonal vectors. Christoffel symbols and their properties, law of transformation law of Christoffel symbols.

2 Covariant differentiation of tensors, covariant differentiation of sum, difference and product of tensors. Gradient, divergence, curl and Laplacian. Curvilinear coordinate system in E_3 : line element, lengthy of vector, angle between two vectors in E_3 in a curvilinear coordinate system. Basis in a curvilinear coordinate system, reciprocal base, covariant and contravariant components of a vector in E_3, partial derivative of a vector. Sperical and cylindrical coordinate system.

3 Curves in E_3 . Parallel vector fields along a curve in E_3 , parallel vector field in E_3 , parallel vector space in a Riemannian space, parallel vector field in a surface of a Riemannian space. Serret-Frenet formulas.

References:

1. A Text Book of Tensor Calculus-M.C.Chaki: Calcutta Publishers.
2. Tensor Calculus-U.C.De, A.A.Shaikh and J. Sengupta-Narosa.
3. Differentoa Geometry of Curves and Surfaces in E_3(Tensor approach)-U.C.De: Anamaya Publishers

Unit-IV
(Dynamics of Particle)

1 Simple Harmonic Motion, Tangent and normal acceleration. Velocity and acceleration along radial and transverse directions.

3 Central orbits, central forces, motion of a particle under central force. Differential equation in polar and pedal coordinates, velocity under central force. Apse, apsidal distance and apsidal angle.

2.1 Kepler's laws of planetary motion, artificial satellites, Escape velocity, Geo stationary satelite Disturbed orbits.

References:

1. Dynamics of a Particle and of Rigid Bodies-S.L.Lony,Radha Publishing House.
2. Dynamics of Particle and Rigid Bodies-Chakroborty and Ghosh-U.N.Dhur and Sons

Integrated Master Degree(IMD)

in

MATHEMATICS

Paper-VIII

(Practical)

Group-A

(Numerical Analysis)

1. Problems on Newton's forward and Backward interpolation. Lagrange interpolation formula. Inverse interpolation. Finding root of a equation by interpolation method.
2. Differentiation formula based on Newton's forward and backward interpolation formula.
3. Numerical integration by Trapezoidal, Simpson's 1/3 rule and Weddle's rule.
4. Finding roots of an equation by Bisection method, Regula Falsi method, fixed point iteration method, Newton-Raphson method.
5. Solution of linear equation by Gauss elimination method, Gauss-Jordan method and Gauss-Siedel method.
6. Finding inverse of a third order matrix without finding its determinant.
7. Runge-Kutta Method

Group-B

(C-Programming)

1. Ascending / Descending order. Finding Largest / smallest.
2. Sum of finite series.
3. Sum of Convergent series.
4. Bisection method.
5. Checking whether a number is prime or not. Generation of prime numbers.
6. Solution of Quadratic equation
7. Newton's forward and Backward interpolation. Lagrange interpolation.
8. Bisection method. Newton-Raphson method. Regula Falsi method.
9. Trapezoidal Rule. Simpson's 1/3 rule.
10. Value of Determinant.
11. Matrix sum, subtraction, product, transposition.
12. Cramer's Rule (upto three variables).
13. Solution of linear equation by Gause elimination method, Gause-Jordan method.
14. Runge-Kutta Method.
15. Mean, variance, correlation coefficient, equation of regression lines.

TRIPURA UNIVERSITY
DEPARTMENT OF MATHEMATICS
PROPOSED NEW MSc CURRICULUM-2015

CORE COURSES

Course Code	Name of the Courses	Credits
MATH 701C	Real Analysis	4
MATH 702C	Complex Analysis	3
MATH 703C	Ordinary Different Equations & Partial Different Equations	4
MATH 801C	Abstract Algebra	4
MATH 802C	Topology	4
MATH803C	Mathematical Methods	3
MATH 901C	Fuzzy Set Theory	3
MATH 902C	Functional Analysis	4
MATH 903C	Computer Programming(C and MATLAB)	2
MATH904C	Numerical Analysis	2
MATH 905C	Project-I	4
MATH 1001C	Lebesgue Measure and Integration	3
MATH 1002C	Numerical Practical through Computer Program (C and MATLAB)	4
MATH 1003C	Project-II	4

DEPARTMENTAL ELECTIVE COURSES

Course Code	Name of the Courses	Credits
MATH 704E	Linear Algebra	4
MATH 705E	Operation Research	4
MATH 706E	Logic	4
MATH 805E	Set Theory	4
MATH 806E	Discrete Mathematics	4
MATH 906E	Advanced Topology	4
MATH 907E	Differential Topology	4
MATH 908E	Rough Sets and Applications	4
MATH 1004E	Fuzzy Logic and Applications	4
MATH 1005E	Fuzzy Topology	4
MATH 1006E	Sequence Space, Summability Theory and its Applications	4
MATH 1007E	Riemannian Geometry	4
MATH 1008E	Algebraic Topology	4
MATH 1009E	Number Theory	4

Compulsory foundation courses

Course Code	Name of the Courses	Credits
MATH804FC	Computer Skills III	4

Elective foundation courses

Course Code	Name of the Courses	Credits
	Craft Work-Jute(Fine Arts Dept)/	2
	Craft Work-Bamboo(Fine Arts Dept)/	2
	Creative Painting(Fine Arts Dept)/	2
	Creative Sculpture(Fine Arts Dept)/	2
	Aesthetics of Music(Music Dept.)/	4
	Yoga(Physical Education Dept.)/	2
	Communicative English(English Dept.)/	2
	NSS/	2
	Social Services	2

A student has to earn minimum 68 credits for getting the Degree of MA/MSc in Mathematics. In one semester a student can earn maximum 20 credits. A student have to earn 48 Credits from core courses of the concerned Department, minimum 16 credits from elective papers in which minimum 4 credits is to be earned from other Department and 4 credits from compulsory Foundation Course. Elective Foundation can be taken by a student out of his/her own interest, which is not compulsory.

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Semester-I	**Credit**	**Semester-II**	**Credit**
MATH701C-Real Analysis	4	MATH801C-Abstract Algebra	4
MATH702C-Complex Analysis	3	MATH802C-Topology	4
MATH703C-Ordinary Differential Equations & Partial Differential Equations	4	MATH803C- Mathematical Methods	3
		MATH804FC- Computer Skills III	4
Semester-III	**Credit**	**Semester-IV**	**Credit**
MATH901C- Fuzzy Set Theory	3	MATH1001C-Lebesgue Measure and Integration	3
MATH902C- Functional Analysis	4	MATH 1002C-Numerical Practical through Computer Programming(C and MATLAB)	4
MATH903C-Computer Programming(C and MATLAB)	2	MATH1003C-Project-II	4
MATH904C-Numerical Analysis	2		
MATH905C-Project-I	4		

TRIPURA UNIVERSITY

DEPARTMENT OF MATHEMATICS

MSc IN MATHEMATICS CURRICULUM-2020

CHOICE BASED CREDIT SYSTEM(CBCS)

CORE COURSES

Course Code	Name of the Courses	Credits
MATH 701C	Linear Algebra	4
MATH 702C	Real Analysis	4
MATH 703C	Complex Analysis	4
MATH 704C	Ordinary Differential Equations	4
MATH 801C	Abstract Algebra	4
MATH 802C	Topology	4
MATH803C	Integral Equations and Calculus of Variations	4
MATH 901C	Functional Analysis	4
MATH 902C	Numerical Analysis	4
MATH 903C	Partial Differential Equations	4
MATH 904C	Project-I	4
MATH 1001C	Lebesgue Measure and Integration	4
MATH 1002C	Computer Programming with practical	4
MATH 1003C	Project-II	4

DEPARTMENTAL ELECTIVE COURSES

Course Code	Name of the Courses	Credits
MATH 705E	Operations Research	4
MATH 706E	Logic	4
MATH 707E	Mathematical Finance	4
MATH 708E	Fuzzy Set Theory	4

MATH 805E	Category Theory	4
MATH 806E	Discrete Mathematics	4
MATH 807E	Fuzzy Logic and Applications	4
MATH 808E	Dynamical Systems	4

MATH 905E	Fuzzy Topology	4
MATH 906E	Set Theory	4
MATH 907E	Differential Topology	4
MATH 908E	Rough Sets and Applications	4
MATH 909E	Abstract Measure Theory	4

MATH 1004E	Classical Mechanics and Fluid Mechanics	4
MATH 1005E	Sequence Space, Summability Theory and its Applications	4
MATH 1006E	Riemannian Geometry	4
MATH 1007E	Algebraic Topology	4
MATH 1008E	Number Theory	4
MATH1009E	Advanced Topology	4
MATH 1010E	Graph Theory	4
MATH 1011E	Fixed Point Theory	4

Compulsory foundation courses

Course Code	**Name of the Courses**	**Credits**
MATH804FC	Computer Skills II	4

Elective foundation courses

Course Code	Name of the Courses	Credits
	Craft Work-Jute(Fine Arts Dept)	2
	Craft Work-Bamboo(Fine Arts Dept)	2
	Creative Painting(Fine Arts Dept)	2
	Creative Sculpture(Fine Arts Dept)	2
	Aesthetics of Music(Music Dept.)	4
	Yoga(Physical Education Dept.)	2
	Communicative English(English Dept.)	2
	NSS	2
	Social Services	2

A student has to earn minimum 80 credits for getting the Degree of MSc in Mathematics. In one semester a student can earn maximum 24 credits. A student have to earn 56 Credits from core courses of the concerned Department, minimum 20 credits from elective papers in which minimum 4 credits is to be earned from other Department and 4 credits from compulsory Foundation Course. Elective Foundation can be taken by a student out of his/her own interest, which is not compulsory.

CORE COURSES

SEMESTER I	SEMESTER II
MATH701C: LINEAR ALGEBRA **MATH702C**: REAL ANALYSIS **MATH703C**: COMPLEX ANALYSIS **MATH704C**: ORDINARY DIFFERENTIAL EQUATIONS	**MATH801C**: ABSTRACT ALGEBRA **MATH802C**: TOPOLOGY **MATH803C**: INTEGRAL EQUATIONS AND CALCULUS OF VARIATION
SEMESTER III	**SEMESTER IV**
MATH901C: FUNCTIONAL ANALYSIS **MATH902C**: NUMERICAL ANALYSIS **MATH903C**: PARTIAL DIFFERENTIAL EQUATIONS **MATH904C** PROJECT-I	**MATH1001C**: LEBESGUE MEASURE AND INTEGRATION **MATH1002C**: COMPUTER PROGRAMMING WITH PRACTICAL **MATH1003C**: PROJECT-II

MATH-701C

LINEAR ALGEBRA

(Credit-4)

1. Matrices and Systems of linear equations: Elementary operations, reduced row-echelon form, consistency of a system of equations, solutions of systems of equations, homogeneous system.

2. Vector spaces: Vector spaces over a field, subspaces, Linear independence and dependence, basis and dimension, coordinates, direct sum.

3. Linear Transformations: Algebra of linear transformations, Rank Nullity Theorem, isomorphism, matrix representation of linear transformation, change of basis, similar matrices, linear functional and dual space.

4. Inner product spaces: Cauchy-Schwarz's inequality, orthogonal and orthonormal basis, Gram-Schmidt orthonormalization, orthogonal projection, projection theorem.

5. Diagonalization: Eigenvalues and eigenvectors, Cayley-Hamilton theorem, Properties of characteristic polynomials, annihilating polynomials, minimal polynomials, diagonalization of matrices, Invariant subspaces , adjoint of an operator, normal, unitary and self adjoint operators, spectral decompositions and spectral theorem, applications of spectral theorem, primary decomposition theorem, Schur's unitary triangularization, Jordon canonical form.

6. Introduction to bilinear and Quadratic forms: Bilinear and quadratic forms, Sylvester's law of inertia.

7. Some applications: LU, QR and SVD decompositions, least square solutions, least square fittings, pseudo inverses.

SUGGESTED READINGS:

1. Gilbert Strang, *Linear Algebra and its Applications*, Cenage Learning

2. Gareth Williams, *Linear Algebra and its Applications*, Jones and Bartlett Publishers.

3. S. Lang, *Linear Algebra*, Undergraduate Texts in Mathematics, Springer-Verlag.

4. S Kumaresan, *Linear Algebra: A Geometric Approach*, PHI.

5. Hoffman and Kunze, *Linear Algebra*, Pearson.

6. Sudhir Kumar Pundir , *A Competitive Approach to Linear Algebra*, CBS Publishers and Distributors.

MATH 702C

REAL ANALYSIS

(Credit-4)

1. Metric Space : Concept of countable and uncountable set, Definitions and examples of metric space, open sphere, closed sphere (elements of point set theory), sequences, Cauchy sequences, Cantor intersection theorem, complete metric space, continuity and compactness, Baire Category theorem , equivalent metric, extension theorem, uniform continuity, connectedness.

2. Functions of bounded variation: Total variation, continuous function of bounded variation, function of bounded variation expressed as the difference of the increasing functions.

3. Riemann – Stieltje's integral: Definitions and examples, integration and differentiation, the upper and lower Darboux-Stieltje's integrals.

4. Fourier series: Expansion of periodic function, Sine series and Cosine series, change of interval, convergence theorem, Riemann – Lebesgue lemma, Bessel's inequality and Parseval's theorem.

SUGGESTED READINGS:

1. W. Rudin, *Principle of Mathematical Analysis*, Mc Grow Hill.

2. T. M. Apostal, *Mathematical Analysis*, Narosa publishing House.

3. M. H. Potter and C. B. Morrey, *A first course in Real analysis*, Springer.

4. D. Somasundaram & B. Choudhury, *A first course in Mathematical analysis*, Narosa publishing House.

MATH 703C

COMPLEX ANALYSIS

(Credit-4)

1. Structure of complex plane, continuity and differentiability of complex function. Analytic function.

2. Complex integration, Cauchy theorem, Cauchy-Goursat theorem. Cauchy integral formula, Cauchy integral formula for higher derivatives, Moreras theorem, Cauchy inequality, Liouville's theorem, Fundamental theorem of Algebra.

3. Sequence and series of functions, power series, Taylor theorem, zeros of an analytic function, Schwarz lemma.

4. Isolated singularity. Laurent's theorem, classification of isolated singularities: pole, essential singularity, removable singularity, residues, Casorati-Weierstrass theorem.

5. Meromorphic function, Rouche's theorem, Inverse function theorem, open mapping theorem, Cauchy residue theorem. Contour integration.

6. Maximum module theorem, convex function, Hadamard three circle theorem. Many-valued function, Branches of many-valued function, branch points. Conformal transformation, Bilinear transformation, cross ratio.

7. Method of analytic continuation, Schwarz reflection theorem, analytic continuation along a curve, power series method of analytic continuation, Monodromy theorem.

8. Harmonic function: Harmonic function on a disk, Harnack' inequality, Harnack' theorem, Poisson integration formula.

SUGGESTED READINGS:

1. J.B.Conway *Functions of a one complex variable*, Narosa publishing house.
2. W.Rudin, *Real and Complex Analysis*, McGraw Hill.
3. H.S.Kasana, *Complex Variable*, Prentice Hall of India.
4. S.Punnusamy, *Foundations of Complex Analysis*, Narosa publishing house.
5. L.V.Ahlfors, *Complex Analysis*, McGraw Hill.
6. J.W. Brown and R.V. Churchill, *Complex Variables and Applications*, McGraw Hill.
7. T.O. Moore and E.H. Hadlock, *Complex Analysis*, Allied Publishers Ltd.

MATH704C

ORDINARY DIFFERENTIAL EQUATIONS

(Credit-4)

1. First Order Differential Equations: Ordinary Differential Equations, mathematical models, first order equations, existence, uniqueness problems, continuous dependence on initial conditions, Gronwall's inequality and applications, Ascoli-Arzoli theorem, theorem on convergence of solution of initial value problem, Picard-Lindeloff theorem, Peano existence theorem, Picard existence and uniqueness theore,. Independence of the solution of linear differential equationexact differential equation and equation of special form.

2. Second Order Linear Differential Equations: Wronskian, explicit methods to find solutions, method of variation of parameters; power series solutions: ordinary points, regular singular points, irregular singular points and Frobenius methods; special functions: Legendre and Bessel functions, properties.

Two-point boundary value problems: Sturm-Liouville equations, Green's functions, construction of Green's functions, nonhomogeneous boundary conditions, eigenvalues and eigenfunctions of Sturm-Liouville equations, eigenfunction expansions, Adjoint and self adjoint boundary value problems.

3. Systems Of Ordinary Differential Equations: Existence and uniqueness theorems; homogeneous linear systems, fundamental matrix, Abel-Liouvelle formula, exponential of a matrix, nonhomogeneous linear systems, linear systems with constant coefficients, Stability of linear systems.

4. Nonlinear Differential Equations: Volterra Prey-Predator model.

Stability for linear systems with constant coefficients, stability of nonlinear systems, method of Lyapunov for nonlinear systems, simple critical points, Poincare's theorem, limit cycles, statement of Poincare-Bendixson theorem, examples.

SUGGESTED READINGS:

1. W. E. Boyce, and R. C. DiPrima, *Elementary Differential Equation and Boundary Value Problems*, 7th Edition, John Wiley & Sons(Asia).
2. S. L. Ross, *Introduction to Ordinary Differential Equations*, John Wiley & Sons.
3. G. F. Simmons, *Differential Equations with Applications and Historical Notes*, McGraw Hill.
4. E. A. Coddington, *An Introduction to Ordinary Differential Equations* (Prentice-Hall).
5. S. J. Farlow, *An Introduction to Differential Equations and Their Applications*, McGraw-Hill.

MATH801C

ABSTRACT ALGRBRA

(Credit-4)

1. Review of basics: Groups, Groups as symmetries, Examples: cyclic, dihedral, symmetric, matrix groups, subgroups, permutation groups, cosets, Lagrange's theorem, Normal subgroups, quotient groups, G/Z(G) theorem.

2. Group homomorphisms: Definition and examples, properties of homomorphisms, isomorphisms, isomorphism theorems, Cayley's theorem, automorphisms of groups, inner automorphisms.

3. Direct products: Definition and examples of external direct products, properties of external direct products, definition and examples of internal direct products, fundamental theorem of finite Abelian groups and applications.

4. Group Action: Definition and examples, properties of group action, Orbits and Satbilizers, Orbit-Stabilizer theorem, Burnside lemma, Extended Cayley's theorem, Conjugacy classes, class equation, Cauchy theorem, p-groups, Sylow's theorems, Simple groups, determination of all simple groups of order ≤60, Structure of finite Abelian groups, solvable groups, nilpotent groups.

5. Rings: Rings, integral domains, Ideals, Maximal ideal, prime ideal, factor rings, ring homomorphisms.

6. **Polynomial rings**, Factorization theory in integral domains, Principal ideal domain, Euclidean domains, Gaussian domain. Prime elements, irreducible elements, unique factorization domain, Einstein's irreducibility criterion and Gauss's lemma.

7. Fields: Fields, Field extensions, algebraic and transcendental extension, finite fields, Galois Theory.

SUGGESTED READINGS:

1. J. A. Gallian, *Contemporary Abstract Algebra*, Narosa Publishing house.
2. D. S. Dummit & R. M. Foote, *Abstract Algebra*, John Wiley & Sons, Indian reprint.
3. I. N. Herstein, *Topics in Algebra*, John Wiley & Sons, Indian reprint.
4. Lang, S. *Algebra,* Springer India, New Delhi.
5. V. K. Khanna & S. K. Bhambri, *A Course in Abstract Algebra*, Vikas Publishing.
6. M.K. Sen, S. Ghosh, P.S. Mukhopadhyay, *Topics in Abstract Algebra*, Universities Press.

MATH 802C

TOPOLOGY

(Credit-4)

1. **Topological spaces:** Topological structures, accumulation points, closed sets, closure of a set, interior, exterior, boundary, neighbourhood, subspaces, relative topologies. Bases and sub-bases: Base for a topology, sub base, topologies generated by classes of sets, local bases. Net and filters.

2. **Continuity and topological equivalence:** Continuous function, continuity at a point, sequential continuity at a point, open and closed functions, homomorphic spaces, topological properties, topologies induced by functions.

3. Subspaces, sum of topological spaces, product spaces, quotient spaces

4. **Separation axioms:** Separation by open sets, separation axioms and Ti spaces, Urysohn's lemma, completely regular spaces.

5. **Countability:** First countable spaces, second countable spaces, separation spaces and Lindeloff theorem. Hereditary properties.

6. **Compact Spaces:** Covers, compact sets, sub set of a compact space, finite intersection property, compactness and Hausdorff spaces, sequentially compact sets, locally compact sets.

7. **Connectedness:** Separated sets, connected sets, connected spaces, connectedness on the real line.

8. **Metrizable spaces:** Definition and examples, properties, subspaces, product of metrizable spaces.

SUGGESTED READINGS:

1. J.L. Kelly, *General Topology*, Von Nostradon.
2. J.R. Munkres, *Topology: A first Course,* Pearson.
3. K.D. Joshi, *Introduction to General Topology*, New Age International.
4. S.W. Davis, *Topology*, Tata McGraw Hill.
5. S. Willard, *General Topology*, Dover Publications.

MATH 803C

INTEGRAL EQUATIONS AND CALCULUS OF VARIATIONS

(Credit 4)

1. Linear integral equations: Volterra integral equations, Fredholm integral equations, Some basic identities, Types of kernels: Symmetric kernel, Separable kernel, Iterated kernel, resolvent kernel, Initial value problems reduced to Volterra integral equations, Solution of Volterra integral equation using Resolvent kernel, Successive approximation, Neumann series method.

2. Boundary value problems reduced to Fredholm integral equations, Solution of Fredholm integral equations using separable kernel, resolvent kernel. Methods of successive approximation and successive substitution to solve Fredholm equations of second kind. Solution of Homogeneous Fredholm integral equation: Eigen values, eigen vectors,

3. Integral transforms for solving integral equations: Basic properties of Laplace transforms, Properties of Laplace Transform, Inverse Laplace Transform, Convolution theorem, Laplace transform of periodic functions, unit step function and impulsive function, Solution of Abel's equation using Laplace transform, Application of Laplace transform to the Solution of Volterra integral equations with convolution type kernels, Solution of integro-differential equations using Laplace transform.

4. Green's function, and Fourier Transforms: Fourier transform, Properties of Fourier transform, inversion formula, convolution, Parseval's equality, Fourier transform of generalized functions, Basic four properties of the Green's function, Procedure for construction of the Green's function by using its basic four properties, Construction of Green's function for boundary value problems, Solution of boundary value problems using Green's function, Reducing boundary value problems to an integral equation using Green's function.

5. 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, Brachistochrone problem, Geodesics.

SUGGESTED READINGS:

1. I.N. Sneddon, *The Use of Integral Transforms*, McGraw Hill.
2. R.R. Goldberg, *Fourier Transforms*, Cambridge University Press.
3. M.G. Smith, *Laplace Transform Theory*, Van Nostrand Inc.
4. L. Elsegolc, *Calculus of Variation*, Dover Publications.
5. R.P. Kenwal, *Linear Integral Equation; Theory and Techniques*, Academic Press.
6. F.B. Hildebrand, *Methods of Applied Mathematics*, Dover Publications.
7. S. Pal and S.C. Bhunia, *Engineering Mathematics*, Oxford University Press.

MATH 901C

FUNCTIONAL ANALYSIS

(Credit: 4)

1. Normed linear spaces, Banach spaces, subspaces, Quotient space of normed linear space and its completeness, equivalent norms, Riesz's lemma.

2. Basic properties of finite dimensional normed linear spaces and compactness, bounded linear transformations, normed linear space of bounded linear transformations.

3. Open mapping and closed graph theorem, Hahn-Banach theorem, Uniform boundedness theorem and some of its consequence

4. Compact operators, weak convergence, dual space, reflexive space, weak sequential compactness.

5. Inner product space, Hilbert space, Orthonormal sets, Bessel's inequality, complete orthonormal sets

6. Riesz representation theorem, Adjoint of an operator on a Hilbert space, reflexivity of Hilbert space. Self-adjoint operators, projection, normal and unitary operators.

SUGGESTED READINGS:

1. B.V. Limaye, *Functional Analysis*, New Age International.

2. E. Kreyszig, *Introduction to Functional Analysis with Applications*, John-Wiley and Sons.

3. J. B. Conway, *A Course in Functional Analysis*, Springer.

MATH 902C

NUMERICAL ANALYSIS

(Credit-4)

1. **Solutions of non linear algebraic equations**: Roots of Polynomial equations: Sensitivity of Polynomial Roots , Steffensen method, Bairstows method of quadratic factors, Graeffe's root squaring method, convergence of methods, rate of convergence.

2. **Matrices and eigen value problem**: LU decomposition of matrices, Power method of extreme eigen values , Jacobi's method for symmetric matrices.

3. **Integration**: Gauss-Legendre and Gaussain Chebyshev's quadrature, Richardson extrapolation, Euler Maclaurin's sum formula, Romberg's integration.

4. **Ordinary Differential equations**: First order equation: existence, uniqueness, stability of solution, Picard method, Euler's method, modified Euler's method, Multi step predictor corrector method, Runge-Kutta method.

SUGGESTED READINGS:

1. S.Ralston A , *A first course in Numerical Analysis*, Mc Graw Hill , N. Y.

2. S.D. Conte, C de Boor, *Elementary numerical analysis (An algorithmic approach)*, MC GrawHill.

3. F. B. Hildebrand, *Introduction to Numerical Analysis*, McGraw Hill N. Y.

MATH 903C

PARTIAL DIFFERENTIAL EQUATIONS

(Credit: 4)

1. First Order P D E: Formation of partial differential equations, Linear, Semi linear & Quasi-linear equations, Lagrange's method, compatible systems, Charpit's method, Cauchy problem for first order partial differential equations.

2. Second Order P D E: Classification of second order PDE's, Linear PDE with constant coefficients, Reducible and irreducible equations, General solution of higher order PDEs with constant coefficients.

3. Second order PDE with variable coefficients, Characteristic curves of second order PDE. Reduction to canonical forms.

4. D'Alembert's solution of wave equation: Solutions of PDE of second order by the method of separation of variables (Laplace, Heat and Wave equations).

SUGGESTED READINGS:

1. I. N. Sneddon, *Elements of Partial Differential Equations*, Dover Publication.

2. E. T. Copson, *Partial Differential Equation*s, Oxford University Press.

3. Piaggio, *Differential Equations* ,CBS. Publishers.

4. P. Prasad, R. Ravindran, *Partial Differential Equations*, New Age.

5. T. Amarnath, *An Elementary course in Partial Differential Equation*s, Narosa Pub.

6. Frank Ayres, *Theory and problems of Differential Equations*, Schaum's Outline Series.

7. B. Epstein, *Partial Differential equations*, McGraw Hill.

MATH 1001C

LEBESGUE MEASURE AND INTEGRATION

(Credit-4)

1. Measurable Sets: Length of Sets, Outer Measure, Lebesgue Measure, properties of measurable sets, Borel Sets & their measurability, further properties of measurable Sets, characterization of measurable sets, non- measurable sets.

2. Measurable Functions: Definitions, properties of measurable functions, step function, operations on measurable functions, characteristic function, simple function, continuous function, sets of measure zero.

3. Borel Measurable Functions: Sequence of Functions, The Structure of Measurable Functions, Convergence in Measure (Egorn Theorem, Lusin's Theorem).

4. Lebesgue Integration : Lebesgue integration of single function, Lebesgue integral of a bounded function, Riemann Integral, comparison of Riemann integral & Lebesgue integral.

5. Properties of the Lebesgue integral for bounded measurable functions: Integral of non-negative measurable functions, general Lebesgue integral, improper integral.

6. Lebesgue Sets: Absolutely continuous functions.

SUGGESTED READINGS:

1. H.L.Royden, *Real Analysis*, Prentice-Hall.

2. W. Rudin, *Principle of Mathematical Analysis*, McGrawHill 1976.

3. P. K. Jain & V. P. Gupta, *Lebesgue Measure & Integration*, New Age International Pvt. Ltd.

MATH1002C

COMPUTER PROGRAMMING WITH PRACTICAL

(Credit: 4)

1. C programming: Review of basic concepts of C, Loops and decisions: for loop, while loop, do-while loop, the break statement, the continue statement, the goto statement.
Arrays and pointers, Structures, Function in C, Bubble sort, selection sort, insertion sort, linear search and binary search, the C pre-processor.

2. MATLAB: Basic Features: Simple Math, The Matlab workspace, About variables, complex number, floating point arithmetic, Mathematical functions. Script M files: Use, Block comments and code cells, startup and finish. Array and Array operations, Numeric data type, Cell Arrays and structures, Character string, Relational and logical operations, Control flow: For loops, while loops, if else end construction, switch case construction, Try catch blocks.

3. Numerical practical with C programming.

4. Numerical practical with MATLAB.

SUGGESTED READINGS:

1. Yashavant Kanetkar, *Let us C*, BPB Publications.

2. E. Balaguruswamy, *Programming in ANSI C* (Tata McGraw-Hill, 2004).

3. Duane Hnselman, Bruce Littlefeild, *Mastering MATLAB 7*, Pearson Education India.

4. William J Palm III, *Introduction to MATLAB 7 for Engineers (Paperback)*, Tata McGraw-Hill.

MATH 705E

OPERATIONS RESEARCH

(Credit-4)

1. **Inventory Control**: Inventory problems and their analytical structure, Economic lot size models with uniform rate of demand, with different rate of demand in different cycle**,** Simple deterministic and stochastic model of inventory control.

2. **Queuing theory**: Basic characteristics of queuing system, Steady-state solutions of Markovian queuing models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space, M/G/1.

3. **Network analysis**: PERT, CPM, Project Crashing, Time cost Trade-off procedure

4. **Advanced topics in Linear Programming**: Revised simplex method, Duality theory, Dual Simplex method, Sensitivity analysis and Parametric Programming.

5. **Integer programming**: Importance of Integer programming problems. Gomory's All IPP technique, Cutting plane algorithm, Branch and bound technique.

6. **Dynamic programming**: Characteristic of Dynamic programming, Bellman's principle of optimality, forward and backward recursive approach, solving linear and non-linear programming problem, solution of inventory problems.

SUGGESTED READINGS:

1. F.S.Hiller & G.C. Leiberman, *Introduction to Operations Research*, McGraw-Hill.

2. G. Hadly, *Nonlinear and Dynamic Programming*, Addison Wesley.

3. Kanti Swarup, P.K. Gupta & Man Mohan, *Operations Research,* Macmillan.

4. K.P.P. Chong, Stanislaw H. Zak, *An Introduction to Optimization*, John Wiley & Sons.

5. J.K. Sharma, *Operations Research: Theory and Applications*, MacMilan India Ltd.

MATH 706E

LOGIC

(Credit-4)

1. Syntax and semantics of propositional logic: Proposition, propositional connectives, truth value and truth table, validity, tautologies, adequate set of connectives.

2. Axiomatic approach of propositional logic: Axiomitazation, Modus-Ponens, deduction theorem, definition of theorem, proof in propositional logic, soundness theorem, compactness theorem, completeness theorem.

3. Syntax of first-order languages: First order languages, Term of a Language, Formulas of a language, First order theories.

4. Semantics of first order languages: Structure of first order languages, truth in structure, Model and elementary classes, embedding and isomorphisms, homogeneous structures, downward Lowenheim-Skolem theorem, definability.

5. Completeness theorem for first order logic: Proofs in first order logic, Metatheorem in first order logic, consistency and compactness, completeness theorem, interpretation in theory.

6. Model theory: Application of the completeness theorem, upward Lowenheim-Skolem theorem, ultra-product of models, applications in algebra, extension of partial elementary maps, elimination of quantifiers and applications, real closed fields and applications in algebra and geometry.

SUGGESTED READINGS:

1. E. Meldelson, *Introduction to Mathematical Logic*, CRC Press, Taylor and Francis Group.

2. Margaris, *First Order Logic*, Dover publications.

3. S.M. Srivastava, *A Course on Mathematical Logic*, Springer.

MATH707E

MATHEMATICAL FINANCE

(Credit-4)

1. Basic concepts of stochastic processes. Concepts of different types of derivatives of a security. Hedging.

2. Brownian motion and Geometric Brownian motion. The Cameron-Martin theorem. Interest rates and present value analysis, continuously varying interest rates. Pricing contracts via arbitrage, the arbitrage theorem, multiperiod model.

3. The Black-Scholes formula, properties of Black-Scholes option cost. Delta hedging arbitrage strategy.

4. European, American and Asian put options. Call option on dividend-paying securities. Estimation of volatile parameters.

5. Valuing by expected utility. The portfolio selection problem. Value at risk and conditional value at risk. Capital assets pricing model.

6. Stochastic order relations. Deterministic and probabilistic optimization problems. Optimization models, the Knapsack problem.

7. Stochastic dynamic programming. Optimal stopping problems.

8. Exotic options. Monte Carlo simulation. Option with nonlinear payoffs. Crude oil data analysis. The Autoregressive model. Mean reversive.

SUGGESTED READINGS:

1. Marek Capinski, Tomasz Zastawniak, *Mathematics for Finance: An Introduction to Financial Engineering*, Springer.
2. John C. Hull, Sankarshan Basu, *Option, Future and Other Derivatives*, 10e, Pearson.
3. David G. Luenberger, *Investment Science*, Oxford University Press.
4. Steven Roman, *Introduction to the Mathematics of Finance, Arbitrage and Option Pricing*, 2e, Springer.
5. Sheldon M. Ross, *Mathematical Finance*, 3e, Cambridge University Press.

MATH 708E

FUZZY SET THEORY

(Credit-4)

1. Interval Arithmetic: Interval numbers, arithmetic operations, rules for operation, distance between intervals.

2. Fuzzy sets: Definition of fuzzy sets, fuzzy point, α-level sets, convex fuzzy sets, basic operations on fuzzy sets, cardinality of fuzzy sets and relative cardinality of fuzzy sets.

3. Operation on Fuzzy sets: Cartesian products, algebraic products, bounded sum and difference, *t*-norms and *t*-conorms, quasi-coincidence of two fuzzy subsets.

4. Generalization and variants of fuzzy sets: *L*-fuzzy sets, interval- valued fuzzy sets, type-2 fuzzy sets, intuitionistic fuzzy sets and set operations of intuitionistic fuzzy sets, Zadeh's extension principle.

5. Fuzzy Arithmetic: Fuzzy numbers, triangular fuzzy numbers, fuzzy numbers describing 'Large', Fuzzy numbers in the set of integers, arithmetic operations on intervals and fuzzy numbers.

6. Fuzzy relations and fuzzy graphs: Fuzzy relations on fuzzy sets, composition of fuzzy relations, max-min and min-max compositions, basic properties of fuzzy relations, relation between max-min and min-max compositions.

7. Fuzzy order: Fuzzy pre-order relations, fuzzy semi-pre-order relations and fuzzy order relations, fuzzy equivalence relations, fuzzy compatibility relations, fuzzy graphs, fuzzy similarity relations, examples of different fuzzy relations.

8. Fuzzy matrix: Sum, multiplication of two fuzzy matrices, idempotent fuzzy matrix and their properties.

9. Decision making: Decision making using fuzzy set and applications.

SUGGESTED READINGS:

1. H. J. Zimmermann, *Fuzzy Set Theory and its applications*, Allied publications Ltd.
2. G. J. Klir and B. Yuan, *Fuzzy sets and Fuzzy Logic*, Prentice Hall of India.
3. G. Bojadziev and M. Bojadziev, *Fuzzy Sets, Fuzzy Logic, Applications*, World Scientific.
4. A. Mukherjee and S. Bhattacharya(Halder), *Fuzzy Set Theory and Fuzzy Topology*, Narosa.

MATH 805E

CATEGORY THEORY

(Credit-4)

1. **Definition of a category:** New category from old. Isomorphisms, monomorphism, epimorphism and bimorphism. Examples.
2. **Constructions on category:** Free category, large category, small category. Initial, terminal and zero objects. Products.
3. **Functors**, Hom-functors, category of categories, Natural transformation and natural isomorphisms, Equivalence of categories, Functor categories, Duality.
4. **Product and coproducts**, Sources and sinks, Limits and colimits, Pullback and pushout.
5. **Inverse and direct limits**, Complete categories, Limits of functor, categories, Universal maps, adjoint functor, existence of adjoints, Monads.
6. **Set valued functors**, Hom-functors, free objects, Algebraic categories and algebraic functors.

SUGGESTED READINGS:

1. Steeve Awodey, *Category Theory*, 2e, Oxford University Press.
2. Robert Goldblatt, *Topoi-The Categorial Analysis of Logic*, Dover Publications.
3. Horst Herrlich, George E. Strecker, *Category Theory*, 3e. Heldermann Verlag.
4. Tom Leinster, *Basic Category Theory*, Cambridge University Press.

MATH806E

DISRECTE MATHEMATICS

(Credit: 4)

1. **Combinatorics:** Permutations and combinations and basic definitions, Pigeon-hole principle, inclusion-exclusion principle, derangements. Generating functions. Polya's enumeration theory. Recurrence relations, Balanced incomplete block design, Difference sets. System of distinct representatives, Orthogonal Latin squares, Hadamard matrices.

2. **Boolean algebra:** Lattices and Algebraic Systems, Principle of Duality, Basic Properties of Algebraic Systems, Distributive and Complemented Lattices, Boolean Lattices and Boolean Algebra, Uniqueness of Finite Boolean Algebra, Boolean expressions and Boolean functions, sum of product, product of sum, minterm, maxterm, minimization of Boolean functions, Karnaugh map method, Design and Implementation of Digital Neworks, Switching Circuits.

SUGGESTED READINGS:

1. L. Lovasz, J. Pelikan, and K. Vesztergombi, *Discrete Mathematics,* Springer.

2. V. K. Balakrishnan, *Introductory Discrete Mathematics,* Dover.

3. R. Johnsonbaugh, *Discrete Mathematics,* Prentice Hall.

4. R. Grimaldi, *Discrete and Combinatorial Mathematics*, Pearson Education.

5. C.L. Liu, *Elements of Discrete Mathematics*, McGraw Hill.

6. Jean-Paul Tremblay, R Manohar, *Discrete Mathematics Structures with Applications to Computer Science*, McGraw Hill.

7. T. Veerarajan, Discrete Mathematics with Graph theory and Combinatorics, McGraw Hill.

MATH807E

FUZZY LOGIC AND APPLICATIONS

(Credit-4)

1. Fuzzy logic: Overview Classical logic, fuzzy propositions, fuzzy quantifiers, linguistic variables and hedges, Inference from conditional fuzzy propositions, inference from conditional and quantified propositions, inference from quantified propositions.

2. Fuzzy membership: Fuzzy triangular membership, trapezoidal membership, direct method with one expert, indirect method with one expert, direct method with multiple experts, indirect method with multiple experts, Fuzzy relation, Fuzzy t-norm, Fuzzy co-norm.

3. Pattern recognition: Fuzzy clustering, Fuzzy pattern recognition, Fuzzy image processing.

4. Fuzzy Decision making: Individual decision making, multi-person decision making, multi-criteria decision making, multi-stage decision making, Fuzzy ranking method.

5. Applications of fuzzy logic:

(a) Fuzzy logic control and Applications, Modeling and control parameter, if then rules, rule evalutions, conflict resolution, defuzzification, washing machine, predator-prey system.

(b) Models of neurons: Neural and fuzzy machine intelligence, fundamental of neural networks, Fuzzy Automata, Fuzzy Dynamic system.

SUGGESTED READINGS:

1. G.J. Klir and B.Yuan, *Fuzzy Sets and Fuzzy Logic*, Prentice Hall of India.

2. G. Bojadziev and M. Bojadziev, *Fuzzy Sets, Fuzzy Logic, Applications*, World Scientific.

3. Yen and Langani, *Fuzzy Logic*, Pearson Education.

MATH 905E

FUZZY TOPOLOGY

(Credit-4)

1. Introduction to Fuzzy topology: Chang's definition and Lowen's definition, basic concepts, fuzzy open sets, fuzzy closed sets, fuzzy interior & fuzzy closure, fuzzy continuous function, lower (upper) semi-continuous functions, their basic properties, subspaces, product spaces, quotient spaces.

2. Induced fuzzy topology: Concept of induced fuzzy topology, weakly induced fuzzy topology–their basic properties, Relation between induced fuzzy topological space and its corresponding topological space, initial topological spaces.

3. Separation axioms in fuzzy topological spaces: Fuzzy T_0-space, fuzzy T_1-space, fuzzy Hausdorff space, fuzzy regular space, fuzzy normal space, properties and examples of these spaces.

4. Fuzzy filter and fuzzy net: Properties of fuzzy filter and fuzzy net, fuzzy filter base and their properties, fuzzy cluster point. Convergence of fuzzy net

5. Fuzzy compact spaces: Fuzzy open cover, α-shading (α*-shading), fuzzy compactness in the sense of Chang, fuzzy compactness in the sense of Lowen, Comparison between different compactness, N – compactness and its properties.

6. Fuzzy connected space and fuzzy countability axioms: Fuzzy countable axioms, qseparated sets, definition of fuzzy connectedness, examples and its properties, good extension of connectedness.

7. Mixed Fuzzy Topology: Definition and Different types of mixed fuzzy topology and their properties

SUGGESTED READINGS:

1. N. Palaniappan, *Fuzzy Topology*, Narosa.

2. H. J. Zimmermann, *Fuzzy Set Theory and its applications*, Allied publications Ltd.

3. L. Ying-Ming and L. Mao-Kang, *Fuzzy Topology, Advances in Fuzzy Systems-Applications and Theory: Volume 9*, World Scientific Publ. 1998.

MATH906E

SET THEORY

(Credit-4)

1. Set and class, Axiomatic set theory, Zermelo-Franklen axiomatic set theory, comparison with other popular axiomatic set theory.

2. Partially ordered set, transfinite set, ordinal numbers, successor ordinal, limit ordinal, transfinite sequence.

3. Cardinal comparability, cardinal numbers, Schroder-Bernstein theorem, Cantor theorem, alephs, cofinality, regular and singular cardinal, limit cardinal, Tarski's theorem, Dedekind finite set.

4. Real numbers, continuum hypothesis(CH), Axiom of Choice(AC), well-ordering principle,

maximum principle.

5. Cardinal arithmetic, sum and product of cardinals, generalized continuum hypothesis(GCH), transitive closure.

6. Transitive models, von Neomann theorem, isomorphism theorem, well foundedness,

reflection principle, Godel operators.

7. Constructible set, Consistency of AC and GCH, Godel's theorems.

SUGGESTED READINGS:

1. E.Meldelson, *Introduction to Mathematical Logic*, 5e. CRC Press, Taylor and Francis Group.

2. K. Kunen, *Set Theory*, Elsevier.

3. A. Levy, *Set Theory*, Dover publications.

4. *Lecture on Set Theory*, Springer, 1970

MATH 907E

DIFFERENTIAL TOPOLOGY

(Credit: 4)

1. Calculus and Manifolds in R^n - Continuity and differentiability of function from R^n to R^m, Inverse function theorem, Implicit function theorem, the existence and uniqueness theorem of solution of ODE.

2. Multivariable integration, Sard's theorem, Exterior Algebra, differential forms, exterior differentiation, integration on singular chain.

3. Manifolds and submanifolds in R^n, tangent space, smooth map between to manifolds, immersion, submersion, embedding.

4. Orientation on manifolds, differential forms on manifolds, integration on manifolds. Concept of manifolds with boundary.

5. Abstract Manifolds – Topological manifolds, Differentiable manifolds, Smooth maps between two manifolds, diffeomorphism. Tangent space: Tangent vector, tangent space,

6. Derivative of a smooth map between two manifolds, Tangent bundle. Immersion, submersion, embedding, submanifold. Regular and critical point, Whitney weak embedding theorem, statement of Whitney embedding theorem, Morse's theorem and Morse function.

7. Vector field, Lie bracket, integral curve of a vector field, flows and local flows, existence of integral curve, complete vector field, existence of complete vector field, vector fields related by a differentiable map.

8. Concept of abstract manifolds with boundary.

SUGGESTED READINGS:

1. A.R. Shastri, *Elements of Differential Topology*, CRC Press.
2. J.R. Muncres, *Analysis on Manifolds*, Addi-Wesley Pub. Co.
3. S. Kumeresan, *A Course in Differential Geometry and Lie Groups*, Hindusthan Book Agencies, New Delhi.
4. U.C. De and A.A. Shaikh, *Differential Geometry of Manifolds*, Narosa Publishing House.
5. D.B. Gauld, *Differential Topology-An Introduction*, Dover Publications.
6. S. Boothby, *An Introduction to Differentiable Manifolds and Riemannian Geometry*, Accademic Press.
7. F.W. Warner, *Foundations of Differentiable Manifolds and Lie Groups*, Springer Verlag.

MATH 908E

ROUGH SETS AND APPLICATIONS

(Credit-4)

1. Rough Sets: Basic concepts of Rough sets, Approximation of sets, rough equality and rough inclusion of sets, comparison of rough sets, core, reduct, knowledge reduction. Algebraic and topological representation of rough sets, generalised approximation spaces, rough sets.

2. Variable Precision Rough Set: Basic concepts, properties, examples; Attribute reduction, significance of attribute reduction.

3. Probabilistic Rough set: Basic concepts, properties, examples; Attribute reduction, significance of attribute reduction.

4. Bayesian Rough set: Basic concepts, properties, examples; Attribute reduction, significance of attribute reduction.

5. Decision Theoretic Rough set: Basic concepts, properties, examples; Attribute reduction, significance of attribute reduction.

6. Applications of Rough Sets:

(a) Decision making, simplification of decision tables, decision algorithm, the case of incomplete information.

(b) Data Analysis, flow graphs, the case of inconsistent data, data mining.

(c) Rough sets and conflict analysis, concepts of conflict theory and applications.

SUGGESTED READINGS:

1. Z. Pawlak, *Rough Sets*, Kluwer Academic Publishers.

MATH909E

ABSTRACT MEASURE THEORY

(Credit-4)

1. Algebra and σ-algebra. Measure spaces. Measurable functions. Integration.

2. Almost everywhere convergence. General Convergence Theorems. Fatou's lemma.

3. Signed measures. Hahn Decomposition Theorem. The Radon-Nikodym Theory. Lebesgue decomposition theorem.

4. L^p-spaces. Riesz Representation theorem.

5. Outer measure and measurability. Caratheodory theorem. Product measures. Fubini's theorem.

6. Inner measure. Caratheodory outer measure. Bair sets and Borel sets. Measure on topological spaces. Hausdorff measures. Borel measures.

SUGGESTED READINGS:

1. G. De Barra, *Measure and Integration*, Woodhead.
2. Sterling K. Berberian, *Measure and Integration*, The Orient Blackswan.
3. H.L. Royden, *Real Analysis*, 3e, PHI.
4. Inder K. Rana, *An Introduction to Measure and Integration*, Narosa.

MATH 1005E

SEQUENCE SPACE, SUMMABILITY THEORY & APPLICATIONS

(Credit-4)

1. Classical sequence spaces: Linear Space, Linear metric spaces, paranorms, semi-norms, norms, subspaces, solidness, symmetric, convergence free, monotone properties of different sequence spaces.
2. Frechet spaces: *FK*-spaces and *BK*-spaces, Schauder basis and *AK*-property, Continuous, Kothe-Toeplitz and generalized Kothe-Toeplitz duals of various sequence spaces.
3. Matrix transformations: Limitation methods, convergence fields, some other matrix transformations of classical sequence spaces.
4. Functional analytic methods: Regular, Conservative and Schur matrices, Continuous and compact linear operators and their applications in matrix transformations.
5. **Summability**: Cesaro means, Special matrix method, Tauberian theorem. Strong and weak convergence of summability methods.

SUGGESTED READINGS:

1. I.J. Maddox, *Element of Functional Analysis*, Cambridge University Press.
2. F. Basar, *Summability Theory and Its Applications*, Bentham Science Publisher.
3. Mursaleen, *Elements of Metric Spaces*, Anamaya Publ. Company.
4. G.M. Peterson, *Regular Matrix Transformations*, McGraw Hill.
5. P.K.Kamthan & M.Gupta, *Sequence spaces and series*, M. Dekker.

MATH1006E

RIEMANNIAN GEOMETRY

(Credit-4)

1. Tensors, Exterior Forms, Covariant derivative, Affine Connection and existence theorem, Torsion and Symmetric connection.

2. Riemannian metric, existence of Riemannian metric, Riemannian connection, existence of Riemannian connection. Riemann curvature, sectional curvature, Ricci tensor, scalar curvature, Schur's theorem.

3. Parallel vector fields and Geodesics, Complete Riemanian Manifolds, Holf-Rinow's

Theorem, Hadamard theorem, Manifolds with constant curvature.

4. Parametrised surface, Gause lemma. Totally geogesic submanifold. First and second variation of arc-lenghth and Energy.

5. Jacobi Vector fields, theorem of Bonnet-Myers and Synge-Weinstein, The theorem of

Rauich, Morse index theorem, the sphere theorem.

6. Riemanian submersion, Isometric immersion: Riemannian submanifol, second fundamental form of a Riemannian submanifold, Gauss equation, Ricci equation, Coddazi equation.

SUGGESTED READINGS:

1. U.C. De and A.A. Shaikh, *Differential Geometry of Manifolds*, Narosa Publishing House.
2. S. Kumeresan, *A Course in Differential Geometry and Lie Groups*, Hindusthan Book Agencies.
3. J.M. Lee, *Introduction to Topological Manifolds*, Springer.
4. A. Mukherjee, *Topics in Differential Topology*, Hindusthan Book Agency.
5. S. Gallot, D. Hulin, J. Lafontaine, *Riemannian Geometry*, Springer Verlag.
6. M.P. do Carmo, *Riemannian Geometry*, Birkhauser.
7. A.A. Kosinski, *Differentiable Manifolds*, Accademic Press.

MATH 1007E

ALGEBRAIC TOPOLOGY

(Credit-4)

1. The Fundamental group: Homotopy, contractible spaces and homotopy type, fundamental group and properties, simply connected spaces, the fundamental groups of circle.

2. Finite Simplicial Complexes: Simplicial complexes, polyhedra and triangulations, simplicial approximation.

3. Simplicial Homology: Orientation of simplicial complexes, simplicial chain complexes and homology, Integral homology groups, Induced homomorphisms, degree of map, invariance of homology groups.

4. Singular chain complex, one-dimensional homology and fundamental groups, Mayer-Vietoris sequence, singular cohomology and cohomology algebra, Chain complexes and homology, exact homology sequence theorem, Covering spaces.

SUGGESTED READINGS:

1. S. De, *Algebraic Topology*, Hindusthan Book Agency.

2. G.E. Bredon,*Topology & Geometry*, Springer.

3. J.M. Lee, *Introduction to Topological Manifolds*, Springer.

4. J.R. Munkres, *Toplogy*, Prentice Hall of India.

5. J.W. Vick, *Homology theory: An Introduction to Algebraic Topology*, Springer Verlag.

6. J.J. Rotman, *An Introduction to Algebraic Topology*, Springer.

7. Hatcher, *Algebraic Topology*, Cambridge University Press.

MATH1008E

NUMBER THEORY

(Credit: 4)

1. Revision of basics: Divisibility, Euclid's Division algorithm, GCD, LCM, Prime numbers, factorization in prime numbers, Fundamental theorem of arithmetic, there are infinite number of primes.

2. Congruences and its elementary properties, Residue classes, linear congruences, complete residue system, reduced residue system, Fermat's theorem, Euler's theorem, Chinese Remainder theorem, Wilson's theorem, Order of an element mod n, Primitive roots and indices, order, necessary and sufficient condition for the existence of primitive roots, construction of reduced residue system, some applications.

3. Quadratic congruences, quadratic residues and non-residues, Quadratic reciprocity, Legendre symbol, Jacobi symbol, some applications.

4. Diophantine equations, linear Diophantine equations, Brahmagupta's equation (also known as Pell's equation), Pythagoras equation, sum of two squares.

5. Divisor functions, perfect numbers, Mobius inversion, Fermat numbers, Mersenne Numbers, finding large primes, Pythagorean triples, Gaussian integers.

6. Greatest integer function (Gauss function), Mobius function, Euler function.

7. Continued fractions, simple continued fractions, approximation of irrational numbers by continued fractions, solution of Pell's equation.

8. Cryptosystems, diagraph transformations and enciphering matrices, RSA Cryptosystem. Primality and Factoring.

SUGGESTED READINGS:

1. D. M. Burton, *Elementary Number Theory*, Tata McGraw-Hill.
2. I. Niven, and H. Zuckerman, *An Introduction to the Theory of Numbers*, Wiley Eastern.
3. Martin Erickson and Anthony Vazzana, *Introduction to Number theory*, Chapman and Hall/CRC.
4. V.K. Krishnan, *Elementary Number Theory- A Collection of Problems with Solutions*, University Press.
5. W.W. Adams and L.J. Goldstein, *Introduction to the Theory of Numbers*, Wiley Eastern, 1972.
6. A. Baker, *A Concise Introduction to the Theory of Numbers*, Cambridge University Press, 1984.
7. Neal Koblitz, *A Course in Number Theory and Cryptology*, Graduate Texts in Mathematics, Springer (1987).

MATH 1009E

ADVANCED TOPOLOGY

(Credit-4)

1. Some important cardinal functions in topology, Perfect mappings.

2. Compact spaces revisited: Locally compact spaces and k-spases. Countably compact spaces, pseudocompact spaces. Sequentially compact spaces.

3. Function Spaces: Pointwise convergence, uniform convergence, compact open topology.

4. Compactifications: Alexandroff compactification theorem. Check-Ston compactification.

5. Check complete spaces, Baire Category theorem. Real-compact spaces.

6. Metrizable spaces: Operations on metrizable spaces. Metrization theorems. Totally bounded spaces. Complete metric spaces. Compactness in metric spaces.

7. Paracompact spaces: Bing's metrization theorem. Moore metrization theorem. Alexandroff's metrization theorem.

8. Connectedness revisited: Different types of disconnectedness.

.

SUGGESTED READINGS:

1. R. Engelking, *General Topology*, Heldermann Verlag.
2. Gillman and Jerison, *Rings of Continuous Functions*, Springer-Verlag.
3. J. Nagata, *Modern General Topology*, North Holland.
4. J. Dugundji, *Topology*, Prentice Hall of India.
5. R.C. Walker,*The Stone-Cech Compactifications*, Springer Verlag.

MATH1010E

GRAPH THEORY

(4 credit)

1. Fundamental concepts: Basic concepts, definitions and examples, degree of vertex, subgraphs, complete graph, matrices and isomorphism, paths, connected graphs, bipartite graphs, extremality vertex degree, the Pigeonhole principal, Turan`s theorem, degree sequences, graphic sequences, degree and digraphs.

2. Tree and Distances: Binary trees, spanning trees, minimal spanning trees, Kruskal's algorithm Properties of tree, distance in graphs, stronger results, disjoint spanning trees, shortest paths, Eulerian circuits.

3. Matching and Factors: Matching in bipartite graphs, maximum matchings, Hall`s matching conditons, Min-Matching in bipartite graphs, sets, applications and algorithms, maximum bipartite matching, weighted bipartite matching, in general graphs, Tutte`s 1-factor theorem,f-factors of graphs.

4. Connectivity and Paths: Cuts, connectivity, edge-connectivity, blocks, 2- connected graphs, connectivity of digraphs, k connected and k-edge connected graphs, applications of Meger`s theorem, Network flow problems maximum network flow, integral flows.

5. Edges and cycles: Line graph and edge-colouring, Hamiltonian cycles: necessary conditions, Sufficient conditions.

SUGGESTED READINGS:

1. Douglas B. West, *Introduction to Graph Theory*, Prentice- Hall.

2. John Clarke and D.A. Holton, *A First Look at Graph Theory*, Allied Publisher.

3. Nora Harsfield and Gerhard Ringel , *Pearls Theory*, Academic Press.

4. Harary, *Graph Theory*, Narosa Publishers.

MATH 1011E

FIXED POINT THEORY

(Credit 4)

1. Contractions: Liupschitzian map, uniqueness of fixed point in compact metric space, Banach's contraction principle, Edelstein Theorem.

2. Fixed point normed linear space: Kranoselsku Theorem, Altman theorem and other Fixed point normed linear spaces.

3. Nonexpansive Maps: Fixed points of nonexpansive maps, Browder fixed point theorem, Gohde fixed point theorem and Kirk's fixed point theorem.

4. Continuation Methods: Continuation methods for contractive mappings, continuation methods nonexpansive mappings,

5. Fixed point in topological space: Homeomorphism, rectract, fixed point results in R^n. Brower fixed point theorem, Schauder fixed point theorem.

6. Fixed points in cones: Nonlinear mappings in cones, linear mappings in cones.

SUGGESTED READINGS:

1. R.P. Agarwal, M. Mechan and D. Oregan, *Fixed Point Theory and Applications*, Cambridge University press.

2. F.F. Bonsall, *Lectures on Some Fixed Point Theorerms of Functional Analysis*, Tata Institute of Fundamental Research, 1962

3. J. Banas and K. Goebel, *Measures of Noncompactness in Banach Space*, Marcel Dekker.