M.Sc. Mathematics
Curriculum & Syllabi (2016)
Curriculum for Master of Science (M.Sc.) Program in Mathematics

I. Program Details

<table>
<thead>
<tr>
<th>Name of Degree</th>
<th>Name of Specialization</th>
<th>Intake (Full-time)</th>
<th>Year of revision (Proposed)</th>
<th>Duration</th>
<th>Eligibility for Admission</th>
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<tr>
<td>M.Sc.</td>
<td>Mathematics</td>
<td>20</td>
<td>2016</td>
<td>2 years (4 semesters)</td>
<td>B.Sc. Degree in Mathematics/ Applied Mathematics/Statistics with first class (60% marks or CGPA 6.5/10) in aggregate in the qualifying examination and for SC/ST candidates 50% marks or CGPA 5.5/10 in aggregate in the qualifying examination</td>
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II. Program Educational Objectives

PEO1: Provide a strong foundation in different areas of Mathematics, so that the students can compete with their contemporaries and excel in the various careers in Mathematics.

PEO2: Motivate and prepare the students to pursue higher studies and research, thus contributing to the ever increasing academic demands of the country.

PEO3: Enrich the students with strong communication and interpersonal skills, broad knowledge and an understanding of multicultural and global perspectives, to work effectively in multidisciplinary teams, both as leaders and team members.

PEO4: Facilitate integral development of the personality of the student to deal with ethical and professional issues, and also to develop ability for independent and lifelong learning.

III. Program Outcomes

PO1: Students will demonstrate in-depth knowledge of Mathematics, both in theory and application.

PO2: Students will attain the ability to identify, formulate and solve challenging problems in Mathematics.

PO3: Students will be able to analyse complex problems in Mathematics and propose solutions using research based knowledge.

PO4: Students will be aware of their professional and ethical responsibilities.

PO5: Students will be able to work individually or as a team member or leader in uniform and multidisciplinary settings.

PO6: Students will develop confidence for self-education and ability for lifelong learning.
## IV. Program Structure

### Semester 1

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<tr>
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**Total credits 70**

**Elective Courses (3 credits, 3 lecture hours)**

1. MA7350 Advanced Topics in Graph Theory
2. MA7351 Advanced Topology
3. MA7352 Algebraic Topology
4. MA7353 Fluid Mechanics
5. MA7354 Fourier Analysis
6. MA7355 Fuzzy Set Theory and Applications
7. MA7356 Generalised Set Theory
8. MA7357 Numerical Linear Algebra
9. MA7358 Operator Theory
10. MA7359 Spectral Theory of Hilbert Space Operators
11. MA7360 Introduction to Fractal Geometry
12. MA7361 Advanced Complex Analysis
13. MA7362 Differential Geometry
14. MA7363 Distribution Theory
15. MA7364 Introduction to Chaos Theory
16. MA7365 Multivariable Calculus
17. MA7366 Numerical Solution for Partial Differential Equations
18. MA7367 Statistical Methods for Quality Management
19. MA7368 Advanced Operations Research
20. MA7369 Stochastic Processes
21. MA7370 Number Theory
22. MA7371 Applied Statistical Inference

23. MA7372 Regression Analysis

24. MA7373 Reliability of Systems

25. MA7374 Forecasting Techniques

Note: Students may also take PG level electives offered by other departments.
Brief Syllabus of Core courses

MA6301 Real Analysis

Real and complex number systems, completeness property, basic topology, Continuity, connectedness and compactness, differentiation, mean value theorems, Taylor’s theorem, Riemann-Stieltjes integral, fundamental theorem of calculus. Uniform convergence, power series, real analytic functions, transcendental functions, equicontinuity, Stone-Weierstrass theorem.

MA6302 Linear Algebra

Vector Spaces, subspaces, dimension, linear transformation, isomorphism, matrix representation, dual space, transpose, Cayley-Hamilton theorem, elementary canonical forms, inner-product space, spectral theorems.

MA6303 Numerical Analysis

MA6304 Ordinary Differential Equations


MA6305 Computer Programming

Basics in C, control statements, functions, arrays, pointers, sorting, structures, basics in C++, constructors and destructors, dynamic arrays, function overloading, operator overloading, friend functions, virtual functions, inheritance.

MA6321 Complex Analysis

Analytic functions, conformal maps, Cauchy’s theorem, Liouville’s theorem, Morera’s theorem, singularities, zeros and poles, Laurent’s series, maximum principle, general form of Cauchy’s theorem, homology, residue theorem, argument principle, harmonic functions, mean-value property, Poisson’s formula, Schwarz reflection principle.
MA6322 Measure and Probability

Measure space, Carathodory’s extension, Lebesgue measure, Lebesgue integration, Lebesgue-Radon-Nikodym theorem, fundamental theorem of calculus, product measure, Fubini’s theorem, joint distribution and marginal distribution of random variables, Chebyshev’s inequality, weak law of large numbers, strong law of large numbers, central limit theorem.

MA6323 Graph Theory

Graphs, trees, metric in graph, connectivity, traversability, matchings, factorization, domination, graph colouring, digraphs, graph algorithms.

MA6324 Abstract Algebra

Group, Lagrange’s theorem, normal subgroup and quotient subgroup, homomorphism, isomorphism. Group of permutations, Cayley’s theorem for finite group, direct product of, group action on a set, Sylow’s theorems, structure of finite abelian group. Ring, integral domain, division ring, field, quotient field of an integral domain, ideals, fundamental theorem of ring homomorphism, isomorphism. Ring of polynomials, Gauss’s lemma, unique factorization domain, principle ideal domain, Euclidean domain, field extension, algebraic extensions, splitting field of a polynomial, algebraic closure.
MA6325 Topology

Topological spaces, subspace topology, continuous functions and sets with imposed topologies, product topology, metric topology, quotient topology, connectedness, compactness, countability axioms, separation axioms, Urysohn Lemma, Urysohn metrization theorem, Tychonoff theorem.

MA7301 Partial Differential Equations


MA7302 Functional Analysis

Normed linear spaces, bounded linear maps, Banach spaces, fundamental theorems, spectrum of a bounded operator, dual space, Riesz representation theorems, weak and weak* convergence, reflexivity, Hilbert spaces, adjoint of a bounded operator, normal operators, unitary operators, self-adjoint operators, spectrum and numerical range.
MA7303 Mathematical Statistics


MA7304 Operations Research


MA7321 Methods in Applied Mathematics

Fourier Series, Integral transforms, Applications of Fourier integrals and transforms, Finite Fourier transforms, Convolution theorem for finite Fourier transforms, Integral equations, Green’ function, Fredholm equation with separable kernels, Eigenvalues and Eigenfunctions, Tensor analysis, Quotient law, Conjugate tensor, Christoffel symbols, Covariant differentiation of tensors, Calculus of variation, Euler’s equation, fundamental lemma of calculus of variation, Functionals involving derivatives higher order, Functionals depending on functions of several independent variables, Rayleigh-Ritz method.
Brief Syllabus of Elective courses

**MA7350 Advanced Topics in Graph Theory**

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Graphs: review of basics in graphs, Connectivity, Traversability, Metric in graph, Convexity, Symmetry, Distance Sequences, Coloring in graphs, vertex coloring, Edge coloring, Total coloring, Complete coloring, Digraphs, Networks, Weighted graphs.

**MA7351 Advanced Topology**

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Topological spaces, subspaces, Continuity, Product topology, Separation Axioms, Covering Properties, Relations between covering properties and separation axioms, Metrizibility and Connectedness, The metrization theorems, Connectedness and total disconnectedness, Homotopy, homotopy of paths, Fundamental group and covering spaces, Deformation retraction.

**MA7352 Algebraic Topology**

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Review of basic Topology, Arcwise connected spaces. Homotopy, homotopy classes, Fundamental group, Change of base point, Topological invariance, Homology groups, Geometrical motivation, Euclidean simplexes, Linear mappings, singular simplexes, chains, Boundary of a simplex, Boundaries and cycles on any space, Homologous cycles and homology groups, Relative homology, Induced Homomorphisms, Topological invariance of homology groups, Homotopic mappings and the homology groups, Prisms, Homology sequences, Simplicial complexes.
MA7353 Fluid Mechanics

Fundamental conceptions about fluids, The Transport Theorem, Continuity equation, Equation of motion, Euler’s equation, Navier-Stokes equations, The energy equation, Dimensional analysis, Boussinesq approximation, Incompressible and irrotational flow, Plane potential flow, Laplace equation, Bernoulli equation, Kelvin’s circulation theorem. Laminar flow, Steady flow, High and low Reynold’s number flows, Boundary layer theory, Blasius solution.

MA7354 Fourier Analysis


MA7355 Fuzzy Set Theory and Applications

Crisp sets and Fuzzy sets, operations on fuzzy sets, Fuzzy arithmetic and Fuzzy relations, Fuzzy measures, Fuzzy Logic and Applications.
**MA7356 Generalised Set Theory**

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**MA7357 Numerical Linear Algebra**

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**MA7358 Operator Theory**

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Banach algebras, Fredholm and semi-Fredhlm operators, Spectral projections, compact operators, Measures of operators, perturbation classes, Unbounded operators, essential spectrum.
MA7359 Spectral Theory of Hilbert Space Operators


MA7360 Introduction to Fractal Geometry

The completeness of space of fractals, transformations Mobius transformations on the Riemann sphere, contraction mapping theorem, dynamical systems, shadowing theorem, chaotic dynamics on fractals. Fractal dimension, Hausdorff-Besicovitch dimension, fractal interpolation, Space filling curves, escape time algorithm, Julia sets, IFS for Julia sets, Application of Julia sets to Newton’s method Invariant sets of continuous open mappings, map of fractals, Mandelbrot’s sets, Mandelbrot’s sets for Julia sets.

MA7361 Advanced Complex Analysis

MA7362 Differential Geometry


MA7363 Distribution Theory

Test functions and distributions, order of distribution, convergence, derivative of distribution, local equality of distributions, support and singular support, compactly supported distributions, structure theorems, Fourier transform, Schwartz class functions, tempered distributions, convolution, Paley-Wiener theorems, fundamental solution of partial differential equations, Malgrange-Ehrenpreis theorem.

MA7364 Introduction to Chaos Theory

MA7365 Multivariable Calculus

Differentiability in several variables, Inverse Function Theorem, Implicit Function Theorem, Rank Theorem, Riemann integration in higher dimensions, Fubini’s Theorem, Green’s theorem, Divergence Theorem, Stokes’ Theorem, Tensors, Differential forms, Integration on chains, Stokes’ Theorem for integrals of differential forms on chains, Differentiable manifolds (as subspaces of Euclidean spaces), Differential forms on manifolds, Integration on manifolds, Stokes’ theorem on manifolds.

MA7366 Numerical Solution for Partial Differential Equations

Classification of PDEs, iterative methods for linear systems and their convergence, initial and boundary value problems, analysis of convergence, consistency and stability, Lax theorem, Von Neumann criterion for stability, numerical methods to solve parabolic, hyperbolic and elliptic partial differential equations.

MA7367 Statistical Method for Quality Management

MA7368 ADVANCED OPERATIONS RESEARCH

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Mathematical programming Problems - Unconstrained optimization - Constrained optimization with equality/ inequality constraints - Quadratic programming- Separable programming, Integer linear programming - Travelling salesman problem- knapsack problem.

MA7369 STOCHASTIC PROCESSES

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Stochastic Processes, Discrete time Markov Chains, Poisson Processes, Birth-Death Processes, Continuous time Markov Chains, Renewal Processes, Queueing theory.

MA7370 NUMBER THEORY

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Divisibility, Euclids lemma, Fundamental theorem of arithmetic, Diophantine equations, Arithmetic functions, Mobius inversion formula, residue systems, Linear congruences, Wilsons theorem, Chinese Remainder theorem, Polynomial congruences, Reduced residue systems, Prime numbers Tchebychevs theorem, Eulers criterion, Legendre and Jacobis symbols, Gauss lemma, Quadratic reciprocity law, Sum of two squares, Sum of four squares, Eulers pentagonal number theorem, Schurs theorem, Gausss circle problem, Dirichlets divisor problem.
MA7371 Applied Statistical Inference

A brief statistical inference-Uniformly most powerful tests, Invariance in estimation and testing, Admissibility, Minimax and Bayes estimation, Asymptotic theory of estimation, Asymptotic distribution of likelihood ratio statistics, Sequential estimation, Sequential probability ratio test. An introduction to categorical data, Two-way contingency tables, Table structure for two dimensions, Way of comparing proportions, Measures of associations, Sampling distributions, Goodness of fit tests, Testing independence. Models of binary response variables, Logistic regression, Logistic models for categorical data, Probit and extreme value models, Log-linear models for two and three dimensions, Fitting of logit and log-linear models, Log-linear and logit models for ordinary variables. Regression: A short introduction, Likelihood ratio test, Confidence intervals and hypothesis test, Test for distributional assumptions, Outliers, Analysis of residuals, Model building, Principal component and ridge regression. Lab component: relevant real life problems to be done in statistical packages like SAS, SPSS etc.

MA7372 Regression Analysis

Simple regression- one independent variable (X), assumptions, estimation of parameters, standard error of estimator, testing of hypothesis about regression parameters, standard error of prediction, Testing of hypotheses about parallelism, equality of intercepts, congruence. Extrapolation, optimal choice of X. Diagnostic checks and correction: graphical techniques, tests for normality, uncorrelatedness, homoscedasticity, lack of fit, modifications like polynomial regression, transformations on Y or X, WLS, inverse regression X(Y). Multiple regression: Standard Gauss Markov Setup, Least square(LS) estimation, Error and estimation spaces, Variance- Covariance of LS estimators, estimation of error variance, case with correlated observations, LS estimation with restriction on parameters, Simultaneous estimation of linear parametric functions, Test of Hypotheses for one and more than one linear parametric functions, confidence intervals and regions. Non Linear regression (NLS) : Linearization transforms, their use & limitations, examination of non-linearity, initial estimates, iterative procedures for NLS, grid search, Newton- Raphson , steepest descent,Marquardts methods. Logistic Regression: Logit transform, ML estimation. Tests of hypotheses, Wald test, LR test, score test, test for overall regression, multiple logistic regression, forward and backward method, interpretation of parameters relation with categorical data analysis, generalized linear model: link functions such as Poisson, binomial, inverse binomial, inverse Gaussian, gamma.
MA7373 RELIABILITY OF SYSTEMS

System reliability models, Series/parallel/mixed components, Redundancy techniques, Maintainability, Systems with repair, Hierarchical systems, Economics of reliability engineering, Reliability management, Life testing, Software reliability, Accelerated testing, Reliability allocation problems.

MA7374 FORECASTING TECHNIQUES

Fundamentals of Quantitative Forecasting, Smoothing Methods, Decomposition Methods, Regression and Econometric Methods, Multiple regression, Econometric models and forecasting, ARIMA Models for time-series, The Box-Jenkins Method, Forecasting with ARIMA models. Forecasting and Planning- Forecasting as input to planning and decision making. Comparison and selection of forecasting methods.
MA6301 Real Analysis

Pre-requisites: Nil
Total Hours : 56

Module 1: [11 (L) Hours]
The real number system, supremum and infimum, completeness property, Archimedean property, density of rational numbers, countability, decimal representation. Open sets, closed sets, compact sets, perfect sets, HeineBorel theorem, Bolzano-Weierstrass theorem.

Module 2: [17 (L) Hours]

Module 3: [17 (L) Hours]
Differentiation: Rolle’s theorem, mean value theorem, L’Hôpital’s rule, derivatives of higher order, Taylor’s theorem, partial derivatives. Riemann Stieltjes integral, continuity, change of variable, fundamental theorem of calculus.

Module 4: [11 (L) Hours]

References:

Course Outcome: Students achieve a good grasp of the basic concepts of real analysis.
MA6302 LINEAR ALGEBRA

Pre-requisites: Nil
Total Hours : 56

Module 1: [13 (L) Hours]
Vector space, subspace, linear span of vectors, linear independence and dependence, basis, dimension, row equivalence, computations concerning subspaces.

Module 2: [16 (L) Hours]
Linear transformation, vector space of transformations, isomorphism, representation of a linear transformation by a matrix, linear functionals, double dual of a space, annihilator of a subset, transpose and inverse of a transformation.

Module 3: [12 (L) Hours]
Characteristic values, annihilating polynomials, Cayley-Hamilton theorem, invariant subspaces, direct sum decompositions, invariant direct sums, quotient space.

Module 4: [15 (L) Hours]
Inner-product, inner-product space, orthogonal basis, linear operator, adjoint and self-adjoint operator, normal and unitary operator, spectral theorems.

References:

Course Outcome: Students get a strong foundation in Linear algebra as preparation for subsequent courses in Mathematics.
MA6303 Numerical Analysis

Pre-requisites: Nil
Total Hours : 42

Module 1: [10 (L) Hours]

Module 2: [11 (L) Hours]

Module 3: [11 (L) Hours]
Interpolation: Lagrange interpolation, Neville’s Algorithm, Newton Interpolation, Piecewise interpolation, quadratic and cubic spline interpolation, Hermite interpolation. Least squares approximation.

Module 4: [10 (L) Hours]

References:

Course Outcome: Understand the fundamental concepts of numerical analysis and methods.
MA6304 ORDINARY DIFFERENTIAL EQUATIONS

Pre-requisites: Nil
Total Hours : 42

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Module 1: [12 (L) Hours]

Module 2: [9 (L) Hours]

Module 3: [11 (L) Hours]
Power series solutions of second-order equations, Legendre equation and Legendre polynomials, second order with regular and singular points, Frobenius method, Bessel function and its properties, Sturm-Liouville problem.

Module 4: [10 (L) Hours]

References:


Course Outcome: Understand linear and non-linear differential equations and methods of solutions. Get an idea to formulate a real world problem using ODEs or system of ODEs.
MA6305 Computer Programming

Pre-requisites: Nil

Total Hours : 70

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Module 1: [7 (L) + 9(P) Hours]
Basics in C, data types, C character set, operators and expressions, control statements, branching, looping, library functions, functions, recursive functions, sorting.

Module 2: [7(L) + 12(P) Hours]
Strings, arrays, multidimensional arrays, passing arrays to functions, pointers, pointers to pointers, arrays using pointers, functions and pointers, structures, unions, structures and pointers.

Module 3: [6(L) + 9(P) Hours]
Basics in C++, object oriented programming, classes and objects, constructors and destructors, constructors with default arguments, dynamic arrays in C++.

Module 4: [8(L) + 12(P) Hours]
Friend functions, In-line functions, function overloading, operator overloading: overloading arithmetic, relational, increment, decrement operators, inheritance, virtual functions.

References:

Course Outcome: Students learn and get trained for programming in C using strings, functions, pointers, structures. Students learn and get trained in object oriented programming.
MA6321 Complex Analysis

Pre-requisites: Nil
Total Hours : 56

Module 1: [13 (L) Hours]
Complex differentiability, Cauchy-Riemann equations, Comparison between differentiability in the real and complex senses, holomorphic functions, harmonic functions, harmonic conjugates, power series, conformal maps, bilinear transformations.

Module 2: [13 (L) Hours]
Line integral, Goursat’s theorem, Cauchy’s theorem for disc, Cauchy’s integral formula, winding number of a closed curve, Cauchy’s estimate, Liouville’s theorem, fundamental theorem of algebra, Morera’s theorem, Local uniform convergence, Weierstrass convergence theorem.

Module 3: [17 (L) Hours]
Zeros of holomorphic functions, Isolated singularities, Laurent’s series, Riemann’s theorem on removable singularity, pole, residue, evaluation of real integrals, essential singularity, Weierstrass theorem, order of a holomorphic function at a point, meromorphic functions, Riemann sphere, rational functions, argument principle, Rouché’s theorem, open mapping theorem, maximum modulus principle, Schwarz’s lemma, local mapping, inverse mapping, order of a rational function.

Module 4: [13 (L) Hours]
Homotopy and simply connected domain, general form of Cauchy’s theorem, complex logarithm, Runge’s theorem, characterisation of simply connected domains, mean value property of harmonic functions, Poisson’s formula, Schwarz reflection principle.

References:

Course Outcome: Understand important results and techniques of complex function theory.
MA6322 Measure and Probability

Pre-requisites: Nil

Total Hours: 42

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Module 1: [11 (L) Hours]
Algebra of sets, σ-algebra, measure space, Borel σ-algebra, completion of measure, outer measure, Carathodory’s extension, Lebesgue measure, probability measure, limit inferior and limit superior of a sequence of events, measurable functions, random variables, distribution function, Lebesgue integration, monotone convergence theorem, Fatou’s lemma, dominated convergence theorem, $L^p$ spaces.

Module 2: [10 (L) Hours]
Signed measure, Hahn decomposition, Jordan decomposition, total variation, absolute continuity, Lebesgue-Radon-Nikodym theorem, absolutely continuous random variables, probability density function, fundamental theorem of calculus.

Module 3: [10 (L) Hours]
Products of measurable spaces, product measure, monotone class lemma, Fubini’s theorem, joint distribution and marginal distribution of random variables, independence of finite families of events, independence of random variables, independence and expectation.

Module 4: [11 (L) Hours]
Convergence in measure, Egoroff’s theorem, almost sure convergence, convergence in mean, relation between modes of convergence, Chebyshev’s inequality, weak law of large numbers for sequence of independent random variables, Borel-Cantelli lemma, strong law of large numbers, central limit theorem for sequence of iid random variables.

References:

Course Outcome: Students acquire a general overview of the basic results in measure theory, integration and probability.
MA6323 Graph Theory

Pre-requisites: Nil
Total Hours : 42

Module 1: [ 10(L) Hours]
Graphs: subgraphs - paths and cycles- isomorphism- cut vertex- bridge-block- bipartite graph-
complement of a graph- line graph- degree sequence, Trees, Metric in graph: eccentricity - centre-
median- centroid, Matrix representation of graph.

Module 2: [10 (L) Hours]
Connectivity : vertex and edge connectivity- Whitney’s theorem- n - connected graphs- Mengers’
theorem. Traversability : Hamiltonian graphs - Ore’s theorem- Posa’s theorem- other sufficient
conditions for hamiltonicity, Euler graphs, Planar graphs: Euler formula- platonic bodies, Non planar
graphs.

Module 3: [11 (L) Hours]
Matchings : maximum matching-perfect matching-matching in bipartite graphs, Factorisation :
Coverings and independence, 1-factorisation, 2-factorisation, Arboricity, Domination: dominating
set-domination number-total dominating set, total domination number.

Module 4: [11 (L) Hours]
Graph Colouring : chromatic polynomials- The four colour problem- The five colour theorem,
Digraphs: connectedness - acyclic digraph- strong digraphs- tournaments, Directed trees: binary
trees- weighted trees and prefix codes, Graph algorithms.

References:

5. F. Harary, Graph Theory, Narosa Publishing House, 2011

Course Outcome: Students acquire an overview of the concepts and
techniques in Graph Theory.
MA6324 Abstract Algebra

Pre-requisites: Nil
Total Hours : 56

Module 1: [13 (L) Hours]
Binary operation, algebraic structures, group, subgroup, order of an element, cosets and Lagrange’s theorem, generator of group, cyclic subgroup, normal subgroup and quotient subgroup, homomorphism, kernel and image of a homomorphism, isomorphism, homomorphism theorems.

Module 2: [13 (L) Hours]
Dihedral group, Permutation on n-symbol, group of permutations, odd, even and cyclic permutation, transposition, alternating group, Cayley’s theorem for finite group, internal direct product of subgroups and external direct product of groups, group action on a set, Sylow’s theorems, structure of finite abelian group.

Module 3: [14 (L) Hours]
Ring, commutative ring, subring, zero-divisor, characteristic of ring, integral domain, division ring, field, quotient field of an integral domain, ideals, operations on set of ideals: union, intersection, sum, product, maximal ideal, prime ideal, homomorphism, fundamental theorem of ring homomorphism, isomorphism.

Module 4: [16 (L) Hours]
Ring of polynomials, prime element, irreducible element, irreducibility criteria, Gauss’s lemma, unique factorization domain, principle ideal domain, Euclidean function and Euclidean domain, ring of polynomials over a field, field extension, minimal polynomial, algebraic and transcendental element, algebraic extensions, splitting field of a polynomial, algebraic closure.

References:

Course Outcome: Students grasp the fundamental principles and theory concerning basic algebraic structures such as groups, rings, integral domains, fields and extension fields.
MA6325 Topology

Pre-requisites: Nil
Total Hours : 56

Module 1: [14 (L) Hours]
   Topological spaces, basis and sub-basis for a topology, order topology, product topology, subspace topology, quotient topology.

Module 2: [14 (L) Hours]
   Continuous functions, metric topology, compact sets, compact sets in the real line, limit point compactness, sequential compactness, local compactness.

Module 3: [12 (L) Hours]
   Connected sets, connected sets in the real line, components and path components, local connectedness.

Module 4: [16 (L) Hours]
   Countability axioms, separation axioms, Urysohn Lemma, Tietze extension theorem, Urysohn metrization theorem, Tychonoff Theorem.

References:

Course Outcome: Acquire knowledge about Topological spaces, Basis, and other fundamental concepts in Topology.
MA7301 Partial Differential Equations

Pre-requisites: Ordinary differential equations

Total Hours : 42

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Module 1: [11 (L) Hours]
Modelling with partial differential equations, Partial differential equations of first order, Cauchy problem, Linear first order P.D.E., Method of characteristics, Lagrange, Charpit’s and Jacobi’s method

Module 2: [9 (L) Hours]
Partial differential equation of second order, Classification of second order equation, Hyperbolic, Parabolic and Elliptic equations, Linear second order partial differential equations with constant coefficients.

Module 3: [11 (L) Hours]
Parabolic differential equations, One dimensional diffusion equation, Boundary conditions; Dirichlet, Neumann and Robin type boundary conditions, Method of separation of variables, Solutions in cylindrical and spherical equation, The maximum principle for the heat equation.

Module 4: [11 (L) Hours]
Hyperbolic differential equations, One dimensional wave equation, Solution of the wave equation by separation of variables, d’Alembert’s solution, Boundary and initial value problem of two dimensional wave equation, Laplace equation, Harmonic function, Green’s identity, Mean value theorem, Maximum principle, Green’s function

References:

Course Outcome: Learn modelling with partial differential equations and the basics of analytical methods to solve partial differential equations.
MA7302 Functional Analysis

Pre-requisites: Nil
Total Hours : 56

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Module 1: [15 (L) Hours]

Module 2: [15 (L) Hours]
Spectrum of a bounded operator, linear functional, dual space, Riesz representation theorem for $L^p([a,b])$ and $C([a,b])$, transpose of a bounded linear operator, weak and weak* convergence, reflexivity.

Module 3: [13 (L) Hours]
Inner product spaces, orthonormal sets, Hilbert spaces, Bessel’s inequality, Riesz - Fisher theorem, projection operator, Riesz representation theorem.

Module 4: [13 (L) Hours]
Bounded operators on Hilbert spaces, adjoint of a bounded operator, normal operators, unitary operators, self-adjoint operators, spectrum and numerical range.

References:


**Course Outcome:** Students understand the basic results about normed linear spaces and linear transformation defined on these spaces.
MA7303 Mathematical Statistics

Pre-requisites: Nil
Total Hours : 56

Module 1: [15 (L) Hours]
Axioms of Probability, Conditional Probability and Independence, Random Variables, Discrete and
Continuous Random Variables, Moments, Expectation of a Function of a Random Variable, Moment
Generating Function and Characteristic Function.

Module 2: [13 (L) Hours]
Random Vectors, Jointly Distributed Random Variables, Joint Probability Distributions, Conditional
expectation, Bivariate Normal Distribution, Transformations of a Random Variable, Transformations
of Random Vectors, Order statistics, Chebyshev’s Theorem.

Module 3: [15 (L) Hours]
Population and Samples, Sampling Distribution of the Mean and Variance, Point Estimation,
Maximum Likelihood Estimation, Method of Moments, Properties of Estimators, Tests of Hypothesis,
Uniformly Most Powerful (UMP) Tests, Neyman-Pearson Lemma, Inference Concerning One Mean
and Two Means, Inference Concerning One Variance and Two Variances, Inference Concerning One
Proportion and several Proportions, Chi-Square Test for Goodness of Fit.

Module 4: [13 (L) Hours]
Regression and Correlation- Bivariate Relationships, Correlation Coefficient, The Two Variable
Linear Regression Model, Least Square Estimation, Inference in the Two-Variable Linear Regres-
sion Model, Analysis of Variance in the Two Variable Linear Regression Model, Prediction in the
Two Variable Linear Regression Model, The K-Variable Linear Regression Model, Equation-Matrix
Formulation in the K-Variable Model, Partial Correlation Coefficients, Inference in the K-Variable
Equations, Prediction, Some Standard Non-linear Regression Models

References:

Course Outcome: Students learn the fundamentals of Mathematical Statistics, and get equipped in the theory and applications of it.
MA7304 OPERATIONS RESEARCH

Pre-requisites: Linear Algebra

Total Hours : 56

Module 1: [14 (L) Hours]

Module 2: [14 (L) Hours]
Duality in linear programming Dual simplex method- Sensitivity analysis-Bounded variable problem- Transportation problem-Integrity property-MODI Method-Degeneracy -Unbalanced problem Assignment problem-Development of Hungarian method-Routing problems

Module 3: [14 (L) Hours]

Module 4: [14 (L) Hours]
Critical path analysis-Probability consideration in PERT. Distinction between PERT and CPM. Resources Analysis in networking scheduling -Time cost optimization algorithm-Linear programming formulation-Introduction to optimization softwares.

References:


Course Outcome: Students learn mathematical techniques that will help them to understand and analyse managerial problems in industry so that resources (capitals, materials, staffing, and machines) may be utilized more effectively.
MA7321 METHODS IN APPLIED MATHEMATICS

Pre-requisites: Nil
Total Hours : 42

Module 1: [9 (L) Hours]
Fourier Series, Dirichlet’s conditions, convergence theorem, other forms of Fourier series, integral transforms, Fourier integral, Gibbs phenomenon, properties and applications of Fourier transforms, Fourier integral to the Laplace transformation, finite Fourier transforms, finite Fourier sine and cosine transforms, convolution theorem, multiple finite Fourier transforms and applications.

Module 2: [11 (L) Hours]

Module 3: [11 (L) Hours]
Tensor analysis, coordinate transformations, contravariant, covariant and metric tensors, fundamental operation with tensors, quotient law, line element and metric tensors, conjugate Tensor, Christoffel symbols, covariant differentiation of tensors.

Module 4: [11 (L) Hours]
Calculus of variation, method of variations in problems with fixed boundaries, variation of a functional, Euler’s equation, functionals involving derivatives of higher order, functionals depending on functions of several independent variables, variational, problems of constrained extrema, Rayleigh-Ritz method.

References:

Course Outcome: Students acquire an overview of the mathematical tools which are useful in many engineering applications.
Syllabus of Elective courses

MA7350 Advanced Topics in Graph Theory

Pre-requisites: Nil
Total Hours: 42

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Module 1: [9 (L) Hours]

Module 2: [12 (L) Hours]

Module 3: [10 (L) Hours]
- Coloring in graphs - vertex coloring-chromatic number- chromatic polynomial- restricted vertex coloring- uniquely colorable graphs- list coloring, Edge coloring of graphs : the chromatic index and Vizing’s theorem- list edge coloring , Total coloring of graphs, Complete coloring , Achromatic number, Applications of coloring.

Module 4: [11 (L) Hours]

References:

Course Outcome: Strengthening of ability for critical thinking on problem solutions in the area. The student gets trained in breaking down a mathematical problem into simpler statements and synthesize proofs.
MA7351 Advanced Topology

Pre-requisites: MA6325 Topology

Total Hours: 42

Module 1: [10 (L) Hours]

Module 2: [10 (L) Hours]
Separation Axioms and Covering Properties - Separation axioms: Hausdorff, regular, Tychonoff, and normal topological spaces, Covering properties: Compactness, Lindelofness, paracompactness, metacompactness, Relations between covering properties and separation axiom, Normality of paracompact spaces, paracompactness of Lindelof spaces, Preservation of separation and covering properties.

Module 3: [12 (L) Hours]
Metrizibility and Connectedness - The metrization theorems of Urysohn and Bing, Smirnov, Nagata. Connectedness and total disconnectedness: Definitions and examples of connectedness, total disconnectedness, zero-dimensionality. Local properties: Local compactness, local connectedness.

Module 4: [10 (L) Hours]

References:


Course Outcome: Review the fundamentals of Topology. Acquire knowledge about Separation Axioms, Metrizability, Fundamental group, covering spaces and Deformation retraction.
MA7352 Algebraic Topology

Pre-requisites: MA6325 Topology

Total Hours : 42

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Module 1: [10 (L) Hours]

Module 2: [10 (L) Hours]
Fundamental group: Homotopy, homotopy classes, Fundamental group, Change of base point, Topological invariance.

Module 3: [12 (L) Hours]
Homology groups: Geometrical motivation, Euclidean simplexes, Linear mappings, singular simplexes, chains, Boundary of a simplex, Boundaries and cycles on any space, Homologous cycles and homology groups, Relative homology.

Module 4: [10 (L) Hours]
Induced Homomorphisms, Topological invariance of homology groups, Homotopic mappings and the homology groups, Prisms, Homology sequences, Simplicial complexes.

References:

Course Outcome: Acquire knowledge about Homotopy and Homology.
MA7353 Fluid Mechanics

Pre-requisites: Nil
Total Hours: 42

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<th>Module 1: [11(L) Hours]</th>
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<td>Fundamental conceptions about fluids, Some mathematical concepts and notations, Kinematics of fluids, The Transport Theorem, Continuity equation, Equation of motion, Stress tensor, Euler's equation, Navier-Stokes equations.</td>
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<th>Module 2: [11(L) Hours]</th>
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<td>The energy equation, Boundary and initial conditions, Dimensional analysis, Buckingham’s Pi theorem, Transformation of Cartesian Coordinates, Curvilinear Coordinates, Boussinesq approximation.</td>
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<th>Module 3: [10(L) Hours]</th>
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<td>Basic properties of irrotational flow, Incompressible and irrotational flow, Stream lines, Path lines, Streak lines, Plane potential flow, Laplace equation, Bernoulli equation, Application of Bernoulli’s equation, Vorticity dynamics, Kelvin’s circulation theorem.</td>
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<th>Module 4: [10(L) Hours]</th>
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<td>Laminar flow, Steady flow in a pipe, Steady flow between concentric cylinders, Flow due to an oscillating plate, High and low Reynold’s number flows, Creeping flow around a sphere, Boundary layer theory, Similarity solutions, Blasius solution.</td>
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References:


Course Outcome: Learn the properties of fluids and fundamentals of fluid dynamics.
MA7354 Fourier Analysis

Pre-requisites: Nil

Total Hours: 42

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Module 1: [11 (L) Hours]

Module 2: [11(L) Hours]
$L^p$ spaces, Convolution of functions, Young’s inequality, approximate identity, Regularisation of functions, Pointwise convergence, Fourier transform in $L^1(R)$ - Riemann-Lebesgue lemma, Multiplication formula, Inversion, Translations and dilations, Multiplication and differentiation.

Module 3: [10(L) Hours]
Abel means and Poisson kernel, Uniqueness theorem for Fourier transform in $L^1(R)$, Fourier transform in $L^2(R)$, Multiplication formula, Plancherel theorem, Uniqueness theorem in $L^2(R)$, Harmonic functions, Dirichlet problem for the upper half plane, Point wise and norm convergence, Dirichlet problem for the disc.

Module 4: [10(L) Hours]
Eigen functions of Fourier transform, Gaussian, Hermite functions, Schwartz space, Paley-Wiener space Paley-Wiener theorem, Uncertainty principle, Hardy classes, Hardy’s theorem.

References:


Course Outcome: Understand the basic results in the Fourier analysis on Euclidean spaces.
MA7355 Fuzzy Set Theory and Applications

Pre-requisites: Nil

Total Hours : 42

Module 1: [12 (L) Hours]
Crisp sets and Fuzzy sets - Introduction, crisp sets an overview, the notion of fuzzy sets basic concepts of fuzzy sets, membership functions, methods of generating membership functions, defuzzification methods- operations on fuzzy sets - fuzzy complement , fuzzy union, fuzzy intersection, combinations of operations, general aggregation operations.

Module 2: [11 (L) Hours]
Fuzzy arithmetic and Fuzzy relations: Fuzzy numbers- arithmetic operations on intervals- arithmetic operations on fuzzy numbers- fuzzy equations, Fuzzy relations : binary relations, binary relations on a single set, equivalence and similarity relations, compatibility or tolerance relations.

Module 3: [10 (L) Hours]
Fuzzy measures, belief and plausibility measures, probability measures, possibility and necessity measures, possibility distribution - relationship among classes of fuzzy measures.

Module 4: [9 (L) Hours]
Fuzzy Logic and Applications: Classical logic : an overview, fuzzy logic, approximate reasoning - other forms of implication operations - other forms of the composition operations, fuzzy decision making fuzzy logic in database and information systems - fuzzy pattern recognition, fuzzy control systems, fuzzy optimization.

References:

Course Outcome: Provides the basic concepts in fuzzy sets and fuzzy relations.
Enhancement of the ability to solve problems based on fuzzy arithmetic.
MA7356 Generalised Set Theory

Pre-requisites: Nil

Total Hours : 42

Module 1: [10 (L) Hours]
An overview of basic operations on Fuzzy sets and Multisets, Multiset relations, Compositions, equivalence multiset relations and partitions of multisets, Multiset functions, Fuzzy Multisets

Module 2: [11 (L) Hours]
Rough sets, Approximations of a set, Properties of Approximations, Rough membership function, Rough sets and Reasoning from data: Information systems, Decision tables, Dependency of attributes, Reduction of attributes, Indiscernibility matrices and functions.

Module 3: [11 (L) Hours]
Soft sets, Tabular representation of a soft set, Operations with Soft sets: soft subset, complement of a soft set, null and absolute soft sets, AND and OR operations, Union and intersection of soft sets, DeMorgan laws, Applications and soft analysis.

Module 4: [10 (L) Hours]
Fuzzy soft sets, Operations on fuzzy soft sets, Soft fuzzy sets and its properties, Fuzzy rough sets and rough fuzzy sets, Rough multisets, Genuine sets Applications.

References:


Course Outcome: Students get an advanced level understanding of Generalized set structures such as Fuzzy sets, Multisets, Rough sets, Soft sets, Rough multisets, Genuine sets Information systems.
MA7357 Numerical Linear Algebra

Pre-requisites: Nil
Total Hours : 42

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Module 1: [10 (L) Hours]
Review Linear Algebra Basic Concepts, Conditioning and Stability; Condition numbers, Floating point arithmetic , Stability of various algorithms, Linear Equation Solving: Gaussian Elimination, Pivoting, Stability of Gaussian Elimination, Cholesky Factorization, Jordan canonical form and applications.

Module 2: [12 (L) Hours]

Module 3: [10 (L) Hours]
Singular Value Decomposition(SVD), Computing the SVD, applications, QR algorithm for SVD

Module 4: [10 (L) Hours]
Generalized inverses of matrices , computing the Moore- Penrose generalized inverse of a matrix.

References:

Course Outcome: Understand modern methods of numerical linear algebra for solving linear systems and least squares problems.
MA7358 OPERATOR THEORY

Pre-requisites: Functional Analysis

Total Hours: 42

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Module 1: [10 (L) Hours]
Banach algebras, Gelfand theory, C*- algebras the GNS construction, spectral theorem for normal operators, Fredholm operators and its properties, semi-Fredholm operators, product of operators.

Module 2: [10 (L) Hours]

Module 3: [12 (L) Hours]

Module 4: [10 (L) Hours]
Unbounded operators: Basic theory of unbounded self adjoint operators, unbounded Fredholm operators and its properties, essential spectrum, unbounded semi-Fredholm operators, Spectral theorem for an unbounded self adjoint operators.

References:

Course Outcome: Students get an understanding of bounded and unbounded operators.
MA7359 SPECTRAL THEORY OF HILBERT SPACE OPERATORS

Pre-requisites: Nil

Total Hours : 42

Module 1: [10 (L) Hours]
Elements of Hilbert space theory, Bounded linear operators on Hilbert spaces, Bounded linear functionals, projection ,Riesz representation theorem, Adjoint, Self adjoint, Unitary Normal operators.

Module 2: [10 (L) Hours]
Spectral properties of bounded linear operators, Resolvant and spectrum, spectral theory, Complex analysis in spectral theory.

Module 3: [11 (L) Hours]
Compact linear operators, spectral theory of compact self adjoint operators; Formula for the inverse operator, Minimum-maximum Properties of eigenvalues, compact normal operators, Operator equations, Fredholm alternative.

Module 4: [11 (L) Hours]
Spectral properties of bounded self adjoint linear operators, Positive operators, Square root of an operator, Projection operators, spectral family and spectral family of bounded self adjoint linear operator, spectral representation of bounded self adjoint Linear operators, Extension of spectral theorem to continuous.

References:

Course Outcome: Students learn spectral properties of operators defined on Hilbert spaces.
MA7360 INTRODUCTION TO FRAC TAL GEOMETRY

Pre-requisites: Topology, Real Analysis, Measure Theory

Total Hours : 42

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Module 1: [11 (L) Hours]
The matrix space (H(X),h), the completeness of space of fractals, transformations on the real line, affine transformations in the Euclidean plane, Mobius transformations on the Riemann sphere, Analytic transformations, contraction mapping theorem.

Module 2: [11 (L) Hours]
The addresses of points on fractals, continuous transformations from code space to fractals, dynamical systems, dynamics on fractals, equivalent dynamical systems, shadow of deterministic dynamics, shadowing theorem, chaotic dynamics on fractals.

Module 3: [10 (L) Hours]
Fractal dimension, theoretical and experimental determination of fractal dimension, Hausdorff-Besicovitch dimension. Applications for fractal functions, fractal interpolation functions, the fractal dimension of fractal interpolation functions, hidden variable fractal interpolation.

Module 4: [10 (L) Hours]
Space filling curves, escape time algorithm, Julia sets, IFS for Julia sets, Application of Julia sets to Newton’s method Invariant sets of continuous open mappings, map of fractals, Mandelbrot’s sets, Mandelbrot’s sets for Julia sets.

References:


Course Outcome: Students get basic knowledge of fractal geometry and related applications
MA7361 Advanced Complex Analysis

Pre-requisites: Nil
Total Hours : 42

Module 1: [10 (L) Hours]

Module 2: [11 (L) Hours]

Module 3: [11 (L) Hours]
Elliptic Functions, Simply periodic functions, Representation by exponents, Fourier Development, Functions of finite order, Doubly periodic functions, Period Module, Unimodular transformations, Cannonical Basis, General properties of elliptic functions.

Module 4: [10 (L) Hours]
Weierstrass Theory, Germs and Sheaves, Sections of Riemann Surfaces, Analytic continuation along arcs, Homotopic curves, The Monodromy theorem, Branch points, the Picard theorem, sub-harmonic functions, spaces p H and N, factorization theorems, shift operator, conjugate functions.

References:

Course Outcome: Students acquire a better understanding of important concepts and techniques in advanced complex analysis.
MA7362 DIFFERENTIAL GEOMETRY

Pre-requisites: Nil

Total Hours : 42

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Module 1: [11 (L) Hours]

Module 2: [11 (L) Hours]

Module 3: [10 (L) Hours]
Arc lengths and line integrals- Curvature of surfaces, Intrinsic equation of a curve, Linear element, Element of area, Intrinsic geometry.

Module 4: [10 (L) Hours]
Parameterized surfaces- Local Equivalence of surfaces and parameterized surfaces, Differential parameters, Isometric surfaces, Geodesic curvature, normal curvature, minimal surfaces.

References:

Course Outcome: Students get a general overview of the basic results in the theory of differential geometry.
MA7363 DISTRIBUTION THEORY

Pre-requisites: MA7302 Functional Analysis / MA3021 Functional Analysis and Applications

Total Hours : 42

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Module 1: [11 (L) Hours]
Test functions, partition of unity, distributions, order of distribution, convergence of distribution, derivative of distribution, multiplication of distribution by a function.

Module 2: [11 (L) Hours]
Local equality of distributions, support of distribution, singular support of distribution, compactly supported distributions, semi-norms, distributions with point support, structure theorems.

Module 3: [10 (L) Hours]
Fourier transform in $L^1(\mathbb{R})$, Schwartz class functions, Riemann-Lebesgue Lemma, inversion, translations and dilations, multiplication and differentiation, Fourier transform in $L^2(\mathbb{R})$, Plancherel theorem.

Module 4: [10 (L) Hours]
Tempered distributions, convolution, Fourier transform, PaleyWiener theorems, distributions as solution to partial differential equations, fundamental solution, Malgrange-Ehrenpreis theorem.

References:


Course Outcome: Students get a general overview of the basic results in the theory of generalised functions and Fourier analysis.
MA7364 Introduction to Chaos Theory

**Pre-requisites:** Topology, Real Analysis, Functional Analysis

**Total Hours : 42**

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**Module 1: [11 (L) Hours]**

**Module 2: [11 (L) Hours]**

**Module 3: [10 (L) Hours]**

**Module 4: [10 (L) Hours]**
- Preliminary Characterization: visual inspection & frequency spectra, Characterising chaos: Lyapunov exponents & dimension estimates, Attractor reconstruction, Embedding dimension for attractor reconstruction.

**References:**


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**Course Outcome:** Students learn the basic concepts of mathematical theory of chaos and its applications.
MA7365 Multivariable Calculus

Pre-requisites: Nil

Total Hours : 42

Module 1: [11 (L) Hours]
Functions on Euclidean spaces, Differentiability in several variables, Partial and directional derivatives, Chain Rule, Mean Value Theorem, Inverse Function Theorem, Implicit Function Theorem, Rank Theorem.

Module 2: [10 (L) Hours]
Riemann integration in higher dimensions, Fubini’s Theorem, Change of variables, Improper integrals, Line and surface integrals, Green’s theorem, Divergence Theorem, Stokes’ Theorem.

Module 3: [11 (L) Hours]

Module 4: [10 (L) Hours]
Differentiable manifolds (as subspaces of Euclidean spaces), Differentiable functions on manifolds, Tangent spaces, Differential forms on manifolds, Orientations, Integration on manifolds, Stokes’ theorem on manifolds.

References:

Course Outcome: Students get familiarized with the basic results in the analysis of functions of several variables.
MA7366 NUMERICAL SOLUTION FOR PARTIAL DIFFERENTIAL EQUATIONS

Pre-requisites: Nil
Total Hours : 42

Module 1: [11 (L) Hours]

Module 2: [11 (L) Hours]
Parabolic equations: explicit and implicit methods for one and two dimensional parabolic equations, Crank-Nicolson method, numerical examples, weighted average approximation, consistency, convergence and stability, alternate direction method in two dimensions, Peaceman-Rachford scheme, Douglas-Rachford scheme.

Module 3: [10 (L) Hours]
Hyperbolic equations: Finite difference methods for first and second order wave equation, Lax-wendroff explicit method, CFL condition for one and two dimensions, ADI schemes for two dimensional hyperbolic equations, Lax-wendroff method for a system of hyperbolic equations, Wendroff’s implicit approximation, reduction of a first order equation to a system of ordinary differential equations, numerical examples.

Module 4: [10 (L) Hours]
Elliptic equations: Numerical examples: a torsion problem, a heat conduction problem with derivative boundary conditions. Finite differences in polar co-ordinates, techniques near a curved boundary, improvement of the accuracy of the solutions. Analysis of the discretization error of the five-point approximation to Poisson’s equation.

References:

Course Outcome: Students learn numerical solution of partial differential equations with an understanding of convergence, stability and consistency.
MA7367 STATISTICAL METHODS FOR QUALITY MANAGEMENT

Pre-requisites: Mathematical Statistics

Total Hours: 42

Module 1: [12 (L) Hours]

Module 2: [10 (L) Hours]

Module 3: [10 (L) Hours]
Cumulative Sum and Exponentially Weighted Moving Average Control Charts - The Cumulative-Cum Control Charts, The Exponentially Weighted Moving-Average Control Charts, the Moving Average Moving Control Charts, Statistical Process Control Techniques, Process Capability Analysis, Acceptance Sampling for Attributes.

Module 4: [10 (L) Hours]

References:

Course Outcome: Students learn various statistical tools for Management and equip the student in the applications of it for Decision making.
MA7368 Advanced Operations Research

**Pre-requisites:** Linear programming/Basic course in Linear Programming

**Total Hours : 42**

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**Module 1: [11 (L) Hours]**

**Module 2: [11 (L) Hours]**

**Module 3: [10 (L) Hours]**
Quadratic programming- Separable programming-Frank and Wolfe’s method-Kelley’ cutting plane method- Rosen’s gradient projection method-Fletcher-Reeve’s method-Penalty and Barrier method.

**Module 4: [10 (L) Hours]**
Integer linear programming-Gomory’s cutting plane method- Branch and Bound Algorithm- Travelling salesman problem- knapsack problem- Introduction to optimization softwares.

**References:**


**Course Outcome:** Students learn the mathematical techniques to solve decision making problems in order to analyze and understand a system, for the purpose improving its performance.
MA7369 Stochastic Processes

Pre-requisites: Knowledge of elementary probability theory.

Total Hours: 42

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Module 1: [11 (L) Hours]

Module 2: [10 (L) Hours]
Continuous time Markov Chains: Poisson processes and its extensions, Birth and Death processes, Pure birth and pure death processes, Finite state continuous time Markov Chains, Rate matrix, Kolmogorov forward and backward equations, Limiting distribution.

Module 3: [9(L) Hours]
Renewal Processes: Definition of a renewal process and related concepts, Examples of renewal processes, Renewal equation and elementary renewal theorem, Generalizations and variations on renewal processes.

Module 4: [12 (L) Hours]
Queueing Theory: General concepts, $M/M/1$ queue, system size and waiting time distributions, $M/M/1/k$ model, $M/M/c$ and $M/M/\infty$ models, Erlang loss model. Erlang queueing models, the system $M/E_k/1$ and the system $E_k/M/1$, Network of Markovian queues, Jackson networks. The $M/G/1$ queue.

References:


Course Outcome: Students learn elementary stochastic processes and queuing theory.
MA7370 Number Theory

Pre-requisites: Nil

Total Hours : 42

Module 1: [11 (L) Hours]
Fundamental concepts, divisibility, Euclids lemma, Fundamental theorem of arithmetic, continued fractions, Diophantine equations, combinatorial study of $\binom{n}{r}$, Arithmetic functions, Mobius inversion formula.

Module 2: [11 (L) Hours]
Basic properties of congruences, residue systems, Linear congruences, Little Fermat theorem, Wilsons theorem, Chinese Remainder theorem, Polynomial congruences, Reduced residue systems, primitive roots.

Module 3: [10 (L) Hours]
Prime numbers, Properties of $\pi(x)$, Tchebychevs theorem, Eulers criterion, Legendre and Jacobis symbols, Gauss lemma, Quadratic reciprocity law, Consecutive residues, Consecutive triples of quadratic residues.

Module 4: [10 (L) Hours]
Sum of two squares, Sum of four squares, Elementary partitions, Eulers partition theorem, Partition generating functions, Eulers pentagonal number theorem, Schurs theorem, Gausss circle problem, Dirichlets divisor problem.

References:

Course Outcome: Students learn the classical number theory concepts and some results on modular arithmetic, quadratic congruence and additivity in detail.
MA7371 APPLIED STATISTICAL INFERENCE

Pre-requisites: Nil
Total Hours : 42

Module 1: [11 (L) Hours]
Uniformly most powerful unbiased tests, Invariance in estimation and testing, Admissibility, Minimax and Bayes estimation, Asymptotic theory of estimation, Asymptotic distribution of likelihood ratio statistics, Sequential estimation, Sequential probability ratio test.

Module 2: [10 (L) Hours]
Two-way contingency tables, Table structure for two dimensions, Way of comparing proportions, Measures of associations, Sampling distributions, Goodness of fit tests, Testing independence.

Module 3: [10 (L) Hours]
Models of binary response variables, Logistic regression, Logistic models for categorical data, Probit and extreme value models, Log-linear models for two and three dimensions, Fitting of logit and log-linear models, Log-linear and logit models for ordinary variables.

Module 4: [11 (L) Hours]
Regression: Simple, multiple, and non-linear regression, Likelihood ratio test, Confidence intervals and hypothesis test, Test for distributional assumptions, Outliers, Analysis of residuals, Model building, Principal component and ridge regression. Lab component: relevant real life problems to be done in statistical packages like SAS, SPSS etc.

References:

Course Outcome: Students understand the fundamentals of applied statistical inference through categorical data analysis and its applications in science and engineering.
MA7372 Regression Analysis

Pre-requisites: Nil
Total Hours : 42

Module 1: [12 (L) Hours]
Simple regression with one independent variable (X), assumptions, estimation of parameters, standard error of estimator, testing of hypotheses about regression parameters, standard error of prediction, Testing of hypotheses about parallelism, equality of intercepts, congruence. Extrapolation, optimal choice of X. Diagnostic checks and correction: graphical techniques, tests for normality, uncorrelatedness, homoscedasticity, lack of fit, modifications like polynomial regression, transformations on Y or X, WLS, inverse regression X(Y).

Module 2: [10 (L) Hours]
Multiple regression: Standard Gauss Markov Setup, Least square(LS) estimation, Error and estimation spaces, Variance-Covariance of LS estimators, estimation of error variance, case with correlated observations, LS estimation with restriction on parameters, Simultaneous estimation of linear parametric functions, Test of Hypotheses for one and more than one linear parametric functions, confidence intervals and regions.

Module 3: [10 (L) Hours]
Non Linear regression (NLS): Linearization transforms, their use and limitations, examination of non linearity, initial estimates, iterative procedures for NLS, grid search, Newton- Raphson , steepest descent, Marquardts methods.

Module 4: [10 (L) Hours]
Logistic Regression: Logit transform, ML estimation. Tests of hypotheses, Wald test, LR test, score test, test for overall regression, multiple logistic regression, forward and backward method, interpretation of parameters relation with categorical data analysis, generalized linear model: link functions such as Poisson, binomial, inverse binomial, inverse Gaussian, gamma.

References:

Course Outcome: Students learn the fundamentals of regression analysis and its applications in science and engineering.
MA7373 RELIABILITY OF SYSTEMS

Pre-requisites: Nil
Total Hours : 42

Module 1: [11 (L) Hours]
Introduction to reliability, Basic concepts, Cut sets, Path sets, Minimal cut and path sets, Bounds for reliability, Reliability and Quality, Maintainability and Availability, Reliability analysis, Causes of failures, Catastrophic and Degradation failures, Useful life of components, Component reliability and hazard models, Mean time to failure, system reliability models, System with components in series, parallel, $k/n$ systems, System with mixed mode failures.

Module 2: [11 (L) Hours]
Redundancy Techniques, Component v/s unit redundancy, Weakest link techniques, Mixed redundancy, Stand by redundancy, Redundancy optimization, Double failure and redundancy, Maintainability and availability concepts, Two unit parallel system with repair, Signal redundancy, Time redundancy, Software redundancy.

Module 3: [10 (L) Hours]
Hierarchical systems, Path determination method, Boolean Algebra method, Cut set approach, Logic diagram approach, Conditional probability approach, System cost and reliability approximations, Economics of reliability engineering, Economic cost, manufacturing cost, customers cost, Reliability achievement cost models, Depreciation cost models, Reliability management, Management policy and decisions.

Module 4: [10 (L) Hours]
Life testing: Introduction, hazard rate functions, Exponential distribution in life testing, Simultaneous testing-stopping at r-th failure, Stopping by fixed time, sequential testing, Accelerated testing, Equipment Acceptance testing, Software reliability, Software reliability models, Reliability Allocation, A two sample problem.

References:

Course Outcome: Students learn the fundamentals of system reliability theory and applications in science and engineering.
MA7374 Forecasting Techniques

Pre-requisites: Nil

Total Hours : 42

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Module 1: [10 (L) Hours]

Module 2: [11 (L) Hours]
Decomposition Methods, Trend Fitting, The Ratio-to-Moving Averages Classical Decomposition Method, Different Types of Moving Averages, Regression and Econometric Methods- Simple Regression and Correlation Analysis, Multiple Regression- Multiple Linear Regression, Selecting Independent Variables and Model Specification, Multicollinearity, Multiple Regression and Forecasting, Econometric Models and Forecasting, Applications.

Module 3: [11 (L) Hours]

Module 4: [10 (L) Hours]

References:


Course Outcome: Students acquire a knowledge of different forecasting techniques, and get equipped in the theory and applications of forecasting techniques for decision making.