# Scheme and Credit Structure of M.Sc. Mathematics

**Department of Applied Sciences**

**The NorthCap University**

**Gurugram**

# M.Sc. Mathematics

# Scheme

# 2019-21

**SCHEME OF M.Sc. MATHEMATICS 2019-2021**

| Sem | | Course Code - Course Name- L-T-P(C) | | | | | GPA | Contact Hours Per Week | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | **Course 1** | **Course 2** | **Course 3** | **Course 4** | **Course 5** | **Course 6** | | | |
| **I** | MAL501 Advanced Linear Algebra 3-0-2(4) | MAL503 Ordinary Differential Equations 3-1-0(4) | MAL515 Computing and Programming 3-0-2(4) | MAL507 Complex Analysis 3-1-0(4) | MAL509 Statistical Inferences 3-0-2(4) | | MAR 501 1 | 23 | 21 |
| **II** | MAL502 Functional Analysis 3-1-0(4) | MAL504 Partial Differential Eq. 3-1-0(4) | MAL506 Numerical Analysis& Methods 3-0-2(4) | MAL508 Topology 3-1-0(4) | Programme Elective -1 3-0-2(4) | MAL 512 Creativity and innovation outcome (1) | MAR 502 1 | 22 | 22 |
| **III** | MAL601 Discrete Mathematics & Automata Theory 3-1-0(4) | MAL 603 Methods of Applied Mathematics 3-1-0(4) | MAL 605 Fluid Mechanics 3-1-0(4) | Programme Elective -2 3-0-2(4) (MOOC) | Open Elective -1 3(3) | MAD 609 Project 1 0-0-4(2) | MAR 601 1 | 20 | 22 |
| **IV** | MAL602 Mathematical Programming 3-1-0(4) | MAL614 Measure Theory 3-1-0(4) | Programme Elective-3 3-0-2 (4) (MOOC) | Open Elective-2 3 (3) | MAL 616 Research Methodology 2-1-0 (3) | MAD 610 Project & Dissertation 0-0-8(4) | MAR 602 1 | 19 | 23 |
| | | | | | | Total | | 84 | 88 |

# The Overall credits structure of MSc (Mathematics) 2019-2021

| Credits Structure | |
|---|---|
| **Category** | **Credits** |
| Program Core (PC) | 60 |
| Program Electives (PE) | 12 |
| Open Electives (OE) | 6 |
| Project/Dissertation | 6 |
| General Proficiency | 4 |
| **TOTAL** | **88** |

**Programme Core (PC)**

| Code | Course Name | L-T-P | C |
|---|---|---|---|
| MAL501 | Advanced Linear Algebra | 3-0-2 | 4 |
| MAL502 | Functional Analysis | 3-1-0 | 4 |
| MAL503 | Ordinary Differential Equations | 3-1-0 | 4 |
| MAL504 | Partial Differential Equations | 3-1-0 | 4 |
| MAL505 | Computing & Programming | 3-0-2 | 4 |
| MAL506 | Numerical Analysis and Methods | 3-0-2 | 4 |
| MAL507 | Complex Analysis | 3-1-0 | 4 |
| MAL508 | Topology | 3-1-0 | 4 |
| MAL509 | Statistical Inference | 3-0-2 | 4 |
| MAL512 | Creativity and Innovation Outcome | 0-0-1 | 1 |
| MAL601 | Discrete Mathematics & Automata Theory | 3-1-0 | 4 |
| MAL602 | Mathematical Programming | 3-1-0 | 4 |
| MAL603 | Methods of Applied Mathematics | 3-1-0 | 4 |
| MAL604 | Measure Theory | 3-1-0 | 4 |
| MAL605 | Fluid Mechanics | 3-1-0 | 4 |
| MAL616 | Research Methodology | 2-1-0 | 3 |
| | **Total Credits** | | **60** |

**Programme Electives (PE)**

| Course Code | Course Name | L-T-P | Credits |
|---|---|---|---|
| MAL510 | Statistical Data Analysis | 3-0-2 | 4 |
| CSL535 | Data Structures | 3-0-2 | 4 |
| MAL514 | Database Management System | 3-0-2 | 4 |
| MAL516 | Soft Computing | 3-0-2 | 4 |
| MAL512 | Field & Module Theory | 3-1-0 | 4 |
| MAL607 | Digital Image Processing | 3-0-2 | 4 |
| MAL609 | Mathematical Modeling and Simulation | 3-0-2 | 4 |
| MAL611 | Data Mining | 3-0-2 | 4 |
| MAL613 | Fourier Analysis | 3-1-0 | 4 |
| MAL615 | Regression Analysis | 3-0-2 | 4 |
| MAL617 | Statistical Simulation | 3-0-2 | 4 |
| MAL619 | Multivariate Analysis | 3-0-2 | 4 |
| MAL621 | Measure Theory | 3-1-0 | 4 |
| MAL606 | Optimization Techniques | 3-1-0 | 4 |
| MAL608 | Time Series Analysis | 3-0-2 | 4 |
| MAL610 | Computational Fluid Dynamics | 3-1-0 | 4 |
| MAL612 | Non-linear Programming | 3-1-0 | 4 |
| MAL620 | Selected Topics | 3-0-2 | 4 |

**B. Project**

| | | | |
|---|---|---|---|
| MAD 609 | Project 1 | 0-0-4 | 2 |
| MAD 610 | Project & Dissertation | 0-0-8 | 4 |
| | Total credits | | 6 |

## List Of Electives

| Semester | Course Code | Course Name | L | P | Credits |
|---|---|---|---|---|---|
| II | MAL510 | Statistical Data Analysis | 3 | 2 | 4 |
| II | MAL518 | Data Structures | 3 | 2 | 4 |
| II | MAL514 | Database Management System | 3 | 2 | 4 |
| II | MAL516 | Soft Computing | 3 | 2 | 4 |
| II | MAL615 | Regression Analysis | 3 | 2 | 4 |
| III | MAL607 | Digital Image Processing | 3 | 2 | 4 |
| III | MAL609 | Mathematical Modelling and Simulation | 3 | 2 | 4 |
| III | MAL611 | Data Mining | 3 | 2 | 4 |
| III | MAL613 | Fourier Analysis | 3 | 2 | 4 |
| III | MAL617 | Statistical Simulation | 3 | 2 | 4 |
| IV | MAL606 | Optimization Techniques | 3 | 2 | 4 |
| IV | MAL608 | Time Series Analysis | 3 | 2 | 4 |
| IV | MAL610 | Computational Fluid Dynamics | 3 | 2 | 4 |
| IV | MAL612 | Non-linear Programming | 3 | 2 | 4 |
| IV | MAL619 | Multivariate Analysis | 3 | 2 | 4 |
| IV | MAL621 | Field and Module Theory | 3 | 2 | 4 |

**First Semester**

## MAL 501 ADVANCED LINEAR ALGEBRA

**(3-0-2= 4 Credits)**

Matrices and Norms, Conditions and Stability, Matrix Factorization, Sparse and Banded Systems, Direct and iterative methods for linear system, Error Analysis, Eigen Values, SVD, EOF and their applications, Linear Least Squares Problem.

| | |
|---|---|
| **CO 1** | Students should be able to understand concept of Matrices and its basic properties. |
| **CO 2** | Students should be able to solve system of linear equations using different Direct methods and Indirect methods. |
| **CO 3** | Students should be able to understand about Vector Space and its properties. |
| **CO 4** | Students should be able to understand about Banded systems, Sparse and Singular Value Decomposition. |

## MAL 503 ORDINARY DIFFERENTIAL EQUATIONS

**(3-1-0= 4 Credits)**

Existence and Uniqueness of First and Second Order Equations, Linear Second Order Equations with Variable Coefficients, Numerical methods and difference equations for system of differential equations.

| | |
|---|---|
| **CO 1** | Students should be able to<br>a) Understand the significance of differential equations.<br>b) Frame differential equations and basic terminologies associated with their solutions. |
| **CO 2** | To understand the significance of differential equations, Wronskian and be able to check for the existence and uniqueness of the equations. |
| **CO 3** | To solve and understand linear differential equations with variable coefficients. To understand the significance of homogenous, non-homogenous equations and their existence. |
| **CO 4** | To be able to solve first order differential equation using appropriate numerical methods and be able to make a comparative study between different methods in addition to their stability and convergence. |
| **CO 5** | To be able to understand the concept of difference equations and their solution methodologies |
| | and determine the generating function of difference equations |

## MAL515 COMPUTING and PROGRAMMING

**(3-0-2=4 Credits)**

Class scope and accessing class members, separating interface from implementation, initializing class objects: constructors, default arguments, destructors. Composition: objects as members of classes, friend functions and friend classes, using this pointer, dynamic memory management with operators new and delete, static class members. Operators functions as class members vs. as friend functions, overloading stream-insertion and stream extraction operators, overloading unary operators, overloading binary operators, Base classes and derived classes, protected members, relationship between base classes and derived classes, constructors and destructors in derived classes, public, protected and private inheritance, Introduction to polymorphism, Relationship among objects in an Inheritance hierarchy, abstract classes and

pure virtual functions.

| | |
|---|---|
| **CO 1** | **To understand how C++ improves C with object-oriented features.** |
| **CO 2** | **To learn how to overload functions and operators in C++.** |
| **CO 3** | **To learn significance of pointers in C++** |
| **CO 4** | **To learn how inheritance and virtual functions implement dynamic binding with polymorphism.** |

## MAL 507 COMPLEX ANALYSIS

**(3-1-0= 4 Credits)**

Lebesgue Measure and Integration, Analytic Functions, Cauchy Theorem and Integral Formula, Analytic Continuation and Taylor's theorem, Hurwitz Theorem, Maximum Modulus Theorem and Open Mapping Theorem, Laurent's Theorem, Classification of singularities, Residue theorem and applications, Argument Principle, Theorems of Rouche and Gauss-Lucas, Mobius Transformations.

| | |
|---|---|
| **CO 1** | Establish one-one correspondence between the points on a sphere and the points on a plane. |
| **CO 2** | Form analytic function from Harmonic function, define and classify the type of singularities and generate Taylor and Laurent series from Complex-valued function. |
| **CO 3** | Able to solve Complex integration and important results based on it and the knowledge to obtain zeros of analytic function. |
| **CO 4** | Capable to evaluate the Residue of Complex-valued function at a Finite Point and the Point Infinity and significance on the residue of complex functions. |
| **CO 5** | Understand Meromorphic and Entire Functions and the Important applications based on it. |
| **CO 6** | Able to transform the complex points in z-plane onto the points in w-plane and understand the basic of Measure theory. |

## MAL 509 STATISTICAL INFERENCES

**(3-0-2= 4 Credits)**

Review of Probability and basic theorems, Probability Density Functions, Normal Density function, Chi-square and F-distributions, Sample distributions and Estimators, Hypothesis Testing for mean, Variance and Proportions, Analysis of Variance, Regression.

| | |
|---|---|
| **CO 1** | Students should be able to understand and visualize probability density functions |
| **CO 2** | Students should be able to apply various distributions to real world problems |

| | |
|---|---|
| **CO 3** | Students should be able to understand sampling and its distribution |
| **CO 4** | Students should be able to measure various parameters and their estimations, confidence intervals |
| **CO 5** | Students should be able to state hypothesis for a given problem and do the testing of hypothesis |

**Second Semester**

## MAL 502 FUNCTIONAL ANALYSIS

**(3-1-0= 4 Credits)**

Metric Spaces, Normed Linear Spaces, Banach Spaces, Inner Product Spaces, Hilbert Spaces, Fundamental Theorems of Normed and Banach Spaces, Approximations in Normed Spaces, Spectral theory of bounded self-adjoint linear operators.

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| **CO 1** | To understand concepts of metric spaces. |
| **CO 2** | To understand the notion of completeness of metric spaces. |
| **CO 3** | To solve problems related to normed linear spaces. |
| **CO 4** | To develop understanding of linear operators, linear functionals, their continuity and boundedness. |
| **CO 5** | To further develop theory of Hilbert spaces. |
| **CO 6** | To develop concepts of orthogonality, orthonormality of sets, self-adjoint and unitary operators. |
| **CO 7** | Application of Banach theorem and approximation in normed spaces. |

## MAL 504 PARTIAL DIFFERENTIAL EQUATIONS

**(3-1-0= 4 Credits)**

Second Order PDE, Wave and Heat Equations, Sturm Liouville problems and Eigenvalue Extensions, Elliptic Equations, Green's functions and Integral representations, Variational Methods, Numerical Methods.

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|---|---|
| **CO 1** | To understand concepts of First order PDE. |
| **CO 2** | To understand the classification of PDE. |
| **CO 3** | To solve problems related to Elliptic Differential Equations. |
| **CO 4** | To develop understanding of Parabolic partial differential equations |
| **CO 5** | To further develop theory of Hyperbolic differential equations. |
| **CO 6** | To develop concepts of Green Function and solution pf PDE by Green Function. |
| **CO 7** | Application of Laplace operator and Fourier transform to solve PDE. |

## MAL 506 NUMERICAL ANALYSIS AND METHODS

**(3-0-2= 4 Credits)**

Numerical Schemes for linear and Nonlinear systems, Conditioning and Stability for Sparse and Dense Matrices, Regression and Curve Fit, Numerical Solutions to ODE and PDE, Two point boundary value problems, Shooting and finite difference methods.

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| **CO 1** | Students should be able to understand numerical solutions of non-linear/ transcendental equations |
| **CO 2** | Students should be able to apply various algorithms to solve system of linear equations |
| **CO 3** | Students should be able to approximate mathematical functions and find intermediary values using interpolation and regression techniques |
| **CO 4** | Students should be able to apply numerical techniques for differentiating and integration of non- analytical functions |
| **CO 5** | Students should be able to apply numerical techniques to solve various differential equations of engineering importance |

## MAL508 TOPOLOGY

**(3-1-0= 4 Credits)**

Topological spaces and continuous functions, Connectedness and compactness, Countability and Separation Axioms, Tychoroff Theorem, Metrization theorem and paracompactness, Complete metric spaces and function spaces.

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| **CO 1** | Students will be able to understand basics of topological space and some other properties of topological spaces. |
| **CO 2** | Students will be able to understand continuity, inverse continuity and mappings. |
| **CO 3** | Students will be able to understand connectedness of sets. |
| **CO 4** | Students will be able to understand Separation Axioms and their properties. |
| **CO 5** | Students will be able to understand Metrization and Para-compactness. |

## PROGRAMME ELECTIVE – 1

**(3-0-2= 4 Credits)**

I. **Statistical Data Analysis**
II. **Data Structures**
III. **Database Management System**
IV. **Soft Computing**
V. **Regression Analysis**

**THIRD SEMESTER**

## MAL 601 DISCRETE MATHEMATICS AND AUTOMATA THEORY

**(3-1-0= 4 Credits)**

The foundations: logic, sets and functions, Algorithms, the Integers and Matrices, Mathematical reasoning. Counting, Discrete Probability, Advanced counting Techniques, Recurrence Relations, Relations, Graph and Trees, Boolean Algebra and Finite-State Machines; Automata.

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|---|---|
| **CO 1** | Students should be able to understand concept of Logic, Sets and Relation of functions. |
| **CO 2** | Students should be able to understand concept of Lattice and Boolean Algebra. |
| **CO 3** | Students should be able to understand and solve Graphs. |
| **CO 4** | Students should be able to understand concept of Finite State Automata and Finite State Machine. |

## MAL 603 METHODS OF APPLIED MATHEMATICS

**(3-1-0= 4 Credits)**

Vector Calculus, Tensors, Multiple Integral Theorems and Their Applications, Integral Transform: Laplace, Fourier, Fourier SINE/COSINE, Hankel and Their Inverse Transforms with their applications, Perturbation Methods: Perturbation theory, Regular perturbation theory, Singular perturbation, Integral Equations, Calculus of Variations

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|---|---|
| **CO 1** | An understanding of the concept of tensor and apply it in various problems |
| **CO 2** | An understanding of the concept of integral Transform and apply it in various problems. |
| **CO 3** | Able to identify and solve integral equation |
| **CO 4** | An understanding of the concept of perturbation theory and apply it in various problems. |

## MAL 605 FLUID MECHANICS

**(3-1-0= 4 Credits)**

Introduction to fluid flow, complex potential, Continuity Equation, Euler's equation, Navier-Stokes equations, Boundary layer theory, Turbulent flow and applications.

## PROGRAMME ELECTIVE – 2

**(3-0-2= 4 Credits)**

I. **Digital Image Processing**
II. **Mathematical Modeling & Simulation**
III. **Data Mining**
IV. **Fourier Analysis**
V. **Statistical Simulation**

## OPEN ELECTIVE – 1

**(3 = 3 Credits)**

**MAD 609 PROJECT-1**
**(2 Credits)**

**FOURTH SEMESTER**

## MAL 602 MATHEMATICAL PROGRAMMING
**(3-1-0= 4 Credits)**

Linear Programming Models, Integer Programming, Dynamic Programming, Game Theory, Job Sequencing, Network Analysis, Goal Programming.

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|---|---|
| **CO 1** | Students will be able to understand and analyze managerial problems in industry so that they are able to use resources effectively. |
| **CO 2** | They will be able to frame mathematical models for analysis of real problems in operations research for quantitative analysis of managerial problems in industry. |
| **CO 3** | They will be able to solve linear programming models for various realistic situations using variety of techniques. |
| **CO 4** | They will develop skills to build and solve transportation and assignment problems in operations research. |
| **CO 5** | Students will be in a state to understand the concept of various goals of an industry and their |
| | process to get optimal solution. |
| **CO 6** | To develop skills to design new simple models like CPM to improve decision making and develop critical thinking and objective analysis of decision problems. |

**MAL 614 MEASURE THEORY**

**(3-1-0= 4 Credits)**

Lebesgue measure on $R^n$ : Introduction, outer measure, measurable sets, Lebesgue measure, regularity properties, a non measurable set, measurable functions, Egoroff's theorem, Lusin's theorem. Lebesgue integration: Simple functions, Lebesgue integral of a bounded function over a set of finite measure, bounded convergence theorem, integral of nonnegative functions, Fatou's Lemma, monotone convergence theorem, the general Lebesgue integral Lebesgue convergence theorem, change of variable formula. Differentiation and integration: Functions of bounded variations, differentiation of an integral, absolutely continuity, Lp- spaces: The Minkowski's inequality and Holder's inequality, completeness of Lp, denseness results in Lp; Fourier series: Definition of Fourier series, formulation of convergence problems, L2 theory of Fourier series, convergence of Fourier series.

| | |
|---|---|
| **CO 1** | understand why a more sophisticated theory of integration and measure is needed |
| **CO 2** | show that certain functions are measurable |
| **CO 3** | Construct the Lebesgue Integral |
| **CO 4** | understand properties of the Lebesgue integral; |
| **CO 5** | develop probabilistic concepts (random variables, expectation and limits) within the framework of measure theory. |

**PROGRAMME ELECTIVE – 3**

**(3-0-2= 4 Credits)**

**I. Optimization Techniques**
**II. Time Series Analysis**
**III. Computational Fluid Dynamics**
**IV. Non-linear Programming**
**V. Multivariate Analysis**
**VI. Field and Module Theory**

**OPEN ELECTIVE – 2**

**(3 = 3 Credits)**

**MAL 616 RESEARCH METHODOLOGY**

**(2-1-0=3 Credits)**

Foundations of Research, Scientific Research, Motivation, Research Objectives, Research Designs, Research Processes, Design of Experiments, Understanding Feasibility of Objectives and Processes, Qualitative and Quantitative Research Methods, Data Collection Processes, Biases in Data Collection, Data Pre-processing, Sampling Distribution and Confidence Intervals, Hypothesis Testing, Interpretation of Results, Literature Review, Technical Writing, Citations, IPR, Research Ethics, Reference management software, Plagiarism, Software for Detection of Plagiarism.

| | |
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| **CO1** | Understand and define research problem |

| | |
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| **CO2** | Understand concepts of data collection processes |
| **CO3** | Understand the basics of data analytics |
| **CO4** | Develop technical writing skills |

**MAD 610 PROJECT-2 (Project and Dissertation)**
**(4 Credits)**

## PROGRAMME ELECTIVES

### MAL 510 STATISTICAL DATA ANALYSIS
**(3-0-2= 4 Credits)**

Drawing Statistical conclusions, Inferences using t-Distributions, Comparision among several Samples, Linear combinations & Multiple comparisons of means, Linear regression: a model for the mean, Multiple regression and inferential tools, Model checking and refinement, Strategies for variable selection, ANOVA Adjustment for serial correlation, Logistic Regression.

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|---|---|
| **CO 1** | Students should be able to understand introduction and basics of statistics, sources and types of data. |
| **CO 2** | Students should be able to visualize data through charts and graphs and learn how to explore data. |
| **CO 3** | Students should be able to understand how to apply organizational Interfaces and perform data preconditioning. |
| **CO 4** | Students should be able to perform linear combinations and multiple comparisons of means. |
| **CO 5** | Students should be able to apply linear correlation, independent and dependent variables and the types of correlation. |

### MAL518 DATA STRUCTURES
**(3-0-2= 4 Credits)**

Introduction to Data Structures, Arrays, recursion, Stacks - Operation on Stack, Pointers and Stacks. Queues - Dynamic Implementation using pointers. Static Lists and Linked Lists-Insertion, deletion, Sorting, Singly Linked List, Doubly Linked List. Storage management-Memory Representation, boundary Tag Systems, Storage Allocation. Trees-Binary Tree, Complete Binary Tree, Binary Search

### MAL 514 DATABASE MANAGEMENT SYSTEM
**(3-0-2= 4 Credits)**

What is database system, purpose of database system, view of data, relational databases, database architecture, transaction management, Data Models, The importance of data models, Basic building blocks, Business rules, The evolution of data models, Degrees of data abstraction. Database Design, ER-Diagram and Unified Modeling Language Database design and ER Model: overview, ER-Model, Constraints, ER-Diagrams, ERD Issues, weak entity sets, Codd's rules, Relational Schemas, Introduction to UML Relational database model: Logical view of data, keys, integrity rules. Relational Database design: features of good relational database design, atomic domain and Normalization (1NF, 2NF, 3NF, BCNF).

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|---|---|
| **CO 1** | Identifying contrast between traditional and modern Database Systems, thereby recognizing their applications. |
| **CO 2** | Developing conceptual database design for any real time project by defining the relationship, constraints etc. on entities. |
| **CO 3** | Applying appropriate design techniques to design a good database that meets the user requirement. |
| **CO 4** | Creating a database and devising queries for extracting information from the database using Relational Algebra and SQL. |
| **CO 5** | Applying the concepts of DBMS for developing a backend for a non-trivial project using NoSQL. |
| **CO 6** | Ability to improvise data fetching time by applying indexing concepts. |
| **CO 7** | Understanding the concepts of end-to-end transaction processing in a database. |

**MAL 516 SOFT COMPUTING**

**(3-0-2= 4 Credits)**

Soft Computing: Introduction, requirement, different tools and techniques, usefulness and applications. Neural network, Artificial neural networks and applications, Different artificial neural network models; learning in artificial neural networks; neural network applications in control systems. fuzzy sets and fuzzy logic systems fuzzy reasoning; fuzzy inference systems; fuzzy control; fuzzy clustering; applications of fuzzy systems. Neuro- fuzzy systems: neuro-fuzzy modeling; neuro-fuzzy control. Genetic Algorithms: Simple GA, crossover and mutation, genetic algorithms in search and optimization Applications: Pattern Recognitions, Image Processing, Rough Set Theory, Granular Computing.

**MAL 615 REGRESSION ANALYSIS**

**(3-0-2= 4 Credits)**

Simple and multiple linear regression, Polynomial regression and orthogonal polynomials, Test of significance and confidence intervals for parameters. Residuals and their analysis for test of departure from the assumptions such as fitness of model, normality, homogeneity of variances, detection of outliers, Influential observations, Power transformation of dependent and independent variables. Problem of multicollinearity, ridge regression and principal component regression, subset selection of explanatory variables, Mallow's Cp statistic. Nonlinear regression, different methods for estimation (Least squares and Maximum

likelihood), Asymptotic properties of estimators. Generalised Linear Models (GLIM), Analysis of binary and grouped data using logistic and log - linear models.

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| **CO 1** | Students will able to understand the concept and significance of correlation and regression in practical situations. |
| **CO 2** | Student will able to examine the existence of multiple correlations and regression through different statistic and their uses in practical aspects. |
| **CO 3** | Students will able to understand the concept of Non-Linear Regression models and their application. |
| **CO 4** | Student will able to execute the concepts of Generalized Linear Models of regression. |

**MAL 607 DIGITAL IMAGE PROCESSING**
**(3-0-2= 4 Credits)**

Introduction to Image Processing: Background, Digital Image Representation, Fundamental steps in Image Processing, Elements of Digital Image Processing- Image Acquisition, Storage, Processing, Communication, Display. Digital Image Formation: A Simple Image Model, Geometric Model- Basic Transformation (Translation, Scaling, Rotation), Perspective Projection, Sampling & Quantization - Uniform & Non uniform. Mathematical Preliminaries: Neighbour of pixels, Connectivity, Relations, Equivalence & Transitive Closure; Distance Measures, Arithmetic/Logic Operations, Fourier Transformation, Discrete Cosine & Sine Transform. Image Enhancement: Spatial Domain Method, Frequency Domain Method, Contrast Enhancement -Linear & Nonlinear Stretching, Histogram Processing; Smoothing - Image Averaging, Mean Filter, Low-pass Filtering; Image Sharpening. High- pass Filtering, High-boost Filtering, Derivative Filtering, Homomorphic Filtering Image Restoration: Degradation Model, Discrete Formulation, Algebraic Approach to Restoration- Unconstrained & Constrained; Constrained Least Square Restoration, Restoration by Homomorphic Filtering, Geometric Transformation - Spatial Transformation, Gray Level Interpolation. Image Segmentation: Point Detection, Line Detection, Edge detection, Combined detection, Edge Linking & Boundary Detection - Local Processing, Global Processing via The Hough Transform; Threshold - Foundation, Simple Global Threshold, Optimal Threshold; Region Oriented Segmentation - Basic Formulation, Region Growing by Pixel Aggregation, Region Splitting & Merging

**MAL 609 MATHEMATICAL MODELLING AND SIMULATION**
**(3-0-2= 4 Credits)**

Fundamentals of mathematical modeling, Framework of modeling, Models based on algebraic systems, differential equations, Simulation techniques and software, Structural equations and types, Monte Carlo methods and parametric analysis, Case studies: Biology, medicine, socioeconomic, ecological system etc.

| | |
|---|---|
| **CO 1** | To simplify the real world problem or approximate it by another problem which is quite close to the original problem that can be translated and solved mathematically.. |
| **CO 2** | To formulate the problem in Problem Language. |
| **CO 3** | To think about the entire physical, chemical, biological, social, economic laws that may be relevant to the situation. |
| **CO 4** | To modify either the idealization assumptions or form another structure for the mathematical model when its comparison is not good with the existing problem. |

**MAL611 DATA MINING**
**(3-0-2= 4 Credits)**
Basic Data Mining Tasks, Data Mining Issues, Data Mining Metrics, Data Mining from a Database Perspective. Data Mining Techniques: A Statistical Perspective on Data Mining, Similarity Measures, Decision Trees, Neural Neworks, Genetic Algorithms. Classification: Statistical-Based Algorithms, Distance-Based Algorithms, Decision Tree-Based Algorithms, Neural Network-Based Algorithms, Rule-Based Algorithms, Combining Techniques. Clustering: Similarity and Distance Measures, Hierarchical Algorithms, Partitional Algorithms, Clustering Large Databases, Clustering with Categorical Attributes. Association Rules: Basic Algorithms, Parallel and Distributed Algorithms, Incremental Rules, Advanced Association Rule Techniques, Measuring the Quality of Rules. Advanced Techniques: Web Mining, Spatial Mining, Temporal Mining.

**MAL 613 FOURIER ANALYSIS**
**(3-0-2= 4 Credits)**

Trigonometric series and Fourier series, Wave forms trigonometric polynomials, Sine and Cosine series with monotone coefficients, Evaluation of Fourier Coefficients when function is given in the form of a discrete data. Spaces, Orthonormal systems, Complete orthonormal system, Riesz-Fischer Theorem, Bessel's inequality, Parseval's inequality.Functions of bounded variation, Order of Fourier coefficients, Basic properties of Fourier coefficients, Riemann-Lebesgue lemma, Uniqueness of Fourier coefficients, Completeness of trigonometric systems. Partial sums of Fourier series and their rate of growth, Riemann's Principle of Localization, Convergence tests for Fourier series, Dini's and Jordan's test. Cesaro summability of Fourier series, Fejer's Theorem, Fejer-Lebesgue theorems, Walsh function series: Definition of Walsh series, Relation between Fourier and Walsh series, Function ordering, Walsh function derivation, Wave form synthesis using Walsh & Fourier series. Walsh transformation: Definition, Comparison with Discrete Fourier Transform, Conversion between Discrete Walsh and Fourier transformation, The Fast Walsh Transform, The generalized transform. The Haar Function: Definition, Relation between Walsh and Haar functions, The Fast Haar Transforms, Two dimensional Haar transformation, The Haar Power Spectrum. Applications in Communications and Signal Processing.Grobner basis Algorithm.

**MAL 617 STATISTICAL SIMULATION**
**(3-0-2= 4 Credits)**

Modular break up of systems into subsystems with linkages, some examples.Logical and recurrence relationships, differential equation models, some examples from social and biostatistics. Description of a stochastic system in terms of appropriate random variable sets Generation of uniform and other specified distribution of random variables. Simulation of simple stochastic system. Monte- Carlo methods for estimating numerical solutions of mathematical problems by random experimentation.Precision and accuracy of such solutions.Variance reduction methods.

**MAL 606 OPTIMIZATION TECHNIQUES**
**(3-0-2= 4 Credits)**

Convex sets and functions; affine hull, Kuhn- Tucker conditions, Convex optimizations: Applications and Geometry, Relative interior, Linear optimizations: Applications and Geometry, Discrete optimization, branch and bound and cutting planes, Genetic algorithm, combinatorial optimization, Line Searches and Newton's Methods, Gradient Methods, Pontryagin's maximum principle.

| | |
|---|---|
| **CO 1** | To be able to formulate linear and non linear programming problems and understand concepts of global and local optima. |
| **CO 2** | Develop understanding of convex sets, convex functions and their properties. |
| **CO 3** | To be able to understand necessary and sufficient conditions for a point to be a point og global optima. |
| **CO 4** | Apply methods for line search and multi dimensional search |
| **CO 5** | Apply algorithms for discrete optimization. |
| **CO 6** | To develop an understanding of convergence of an algorithm, it’s stopping criteria, how to compare performance of one algorithm with another algorithm. |

**MAL 608 TIME SERIES ANALYSIS**
**(3-0-2= 4 Credits)**

Linear stationary processes, AR, MA, ARMA and ARIMA; identification, estimation of the models; forecasting time series regression; Fourier analysis, spectral representation of a

stochastic process, properties of ARMA processes in the frequency domain; estimation of the spectrum, Kalman filter.

**MAL 610 COMPUTATIONAL FLUID DYNAMICS**
**(3-0-2= 4 Credits)**
Lagrangian and Eulerian descriptions, Continuity of mass flow, circulation, rotational and irrorational flows. Boundary surface.General equations of motion, Bernoulli's theorem (Compressible, incompressible flows) Kelvin's theorem (constancy of circulation).Stream function, Complex-potential, sources, sinks and doublets, circles theorem, Method of images.Theorem of Blasius. Stoke's stream function, Spherical Harmonics and motion of a sphere. Helmholtz's vorticity equation (permanence of vorticity) Vortex filaments, vortex pair.Navier- Stoke's equations. Dissipation of energy. Diffusion of vorticity, Steady flow between two infinite pipe (Hagen-Poiseuille flow).

**MAL 612 NONLINEAR PROGRAMMING**
**(3-0-2= 4 Credits)**
Overview of non-linear programming, unconstrained problems, global/local optima, convex sets and functions, optimality conditions, stationary points. Gradient methods: motivation and convergence analysis. Armijo step size selection.Linear, sublinear, and super linear convergence.Gradient relatedness and the capture theorem. Newton methods and their convergence. Survey of other unconstrained methods, including conjugate gradient.Optimization over an abstract set. Normal cones, feasible directions and optimality conditions.Variational inequalities. Frank-Wolfe methods and their convergence. Gradient projection methods. Problems with functional constraints.Lagrange multipliers and Kuhn-Tucker conditions.Lagrangian functions. Duality for problems with linear constraints.Barrier methods.Penalty methods. Weak and strong duality for nonlinear problems. Convex duality. Direct Lagrangian methods.Proximal minimization algorithms. Augmented Lagrangian methods and duality.

**MAL 619 MULTIVARIATE ANALYSIS**
**(3-0-2= 4 Credits)**
Multivariate normal distribution, assessing normality, Wishart and Hotelling's T2; Comparisons of several multivariate means, MANOVA; multivariate linear regression models; principal components, factor analysis; canonical correlations; discrimination & classification.

**MAL 621 FIELD AND MODULE THEORY**
**(3-0-2= 4 Credits)**
Perfect fields, Finite fields, Algebraically closed fields, Automorphisms of extensions & Galois extensions. Solution of polynomial equations by radicals, Modules, Cyclic modules, Schuler's Lemma, Free modules. Inseparable extension, Noetherian and artinnian modules, Wedderburn-artin theorem

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| **CO 1** | To appreciate and understand the concept Fields. |
| **CO 2** | To appreciate and understand the concept Fields. |
| **CO 3** | To apply the knowledge and understand the concept of Modules. |