Delhi Technological University
formerly Delhi College of Engineering
(Under Delhi Act 6 2009, Govt. of NCT of Delhi)

Course Outcomes of M.Sc. Mathematics

S. No	Course Code / Course Name / Semester	Course Outcomes
1	(MSMA101) Abstract Algebra (M.Sc. Semester-1)	CO1: Identify different algebraic structures like groups, rings, fields etc. and to apply them in various science related problems.
		CO2: Apply concepts of abstract Algebra with various scientific tools to evolve new ideas to solve practical problems.
		CO3: Analyze special type of ring viz. PID and design ring related applications especially in the field of computer science.
		CO4: Apply algebraic concepts such as groups and ring theory to model, analyze and solve research-based problems.
2	(MSMA102) Complex Analysis (M.Sc. Semester-2)	CO1: Integrate the different concepts and techniques of complex analysis in a comprehensible manner; thus, stimulating new research.
		CO2: Identify the role and applications of complex analysis in mathematical modelling, physics and in many other areas of mathematics such as harmonic analysis and applied scientific computing.
		CO3: Apply appropriate complex analysis techniques in solving science and engineering related problems arising in various fields such as mechanical, electrical and aerospace.
		CO4: Describe use of new techniques of complex analysis in applied mathematics and research oriented applications.
3	(MSMA103) Real Analysis (M.Sc. Semester-1)	CO1: Describe the concepts and properties of sets and categorize sequences and series as convergent, divergent or oscillatory.
		CO2: Construct metric spaces and acknowledge the space of functions in a better way.
		CO3: Analize continuity and uniform continuity and apply their properties to create and establish many real-life continuous functions.
		CO4: Differentiate between convergence and uniform convergence of sequences and series of functions.
		CO5: Solve Riemann integrals and compute the integrals of numerical data derived from real life situations.
4	(MSMA104) Partial Differential Equations (M.Sc. Semester-2)	CO1: Identify the techniques to form linear and non-linear of order one and higher order partial differential equations and evaluate the solutions by various methods.
		CO2: Classify and examine the second order partial differential equations into canonical form.
		CO3: Describe the one and two dimensional heat equation and solve using method of separation of variables and Fourier series.
		CO 4: Solve boundary value problem of Laplace and Poisson's equations, Neumann problem and Dirichlet's problem.
		CO 5: Analyse the physical phenomena of one dimensional wave equation and solve using Fourier series.
5	(MSMA105) Ordinary Differential Equations (M.Sc.	CO1: Classify ordinary differential equations, determine their order and degree, solve constant coefficient equations using various methods, identify existence and uniqueness of initial value problems of first and higher order.
		CO2: Identify ordinary and singular points, calculate power series solutions near ordinary point and regular singular point for important classes of ordinary differential equations including Legendre equation and Bessel's equations.
		CO3: Express higher-order linear differential equations as first-order systems in normal form, solve systems of homogeneous first-order linear differential equations using matrix methods, solve systems of non-homogeneous linear first-order differential equations

	Semester-1)	CO4: Apply Sturm theory, identify oscillatory and non-oscillatory differential equations, estimate the existence and asymptotic behaviour of the eigenvalues, and the corresponding qualitative theory of the eigenfunctions for Sturm–Liouville boundary value problems
		CO5: Sketch trajectories associated with, calculate critical points of, and express understanding of concepts related to phase plane analysis for simple autonomous linear and non-linear systems of equations
6	(MSMA106) Topology (M.Sc. Semester-2)	CO1: Describe Topological spaces and use their properties in different areas of Mathematics.
		CO2: Integrate different techniques of topology in an effective manner to arrive at new and innovative concepts.
		CO3: Develop the ability to think abstractly and demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from topology.
		CO4: Formulate, solve and analyse interdisciplinary current world problems for higher study and research.
7	(MSMA107) Discrete Mathematics (M.Sc. Semester-1)	CO1: Recognize various algebraic structures that can be employed in the fields of engineering and sciences.
		CO2: Formulate mathematical problems via the formal language of propositional logic and predicate logic.
		CO3: Deduce analytically the problem-solving situations in related areas of Theory in Computer Science and Graph Theory.
		CO4: Apply the skills gained to formulate, solve and analyse interdisciplinary real-world problems for higher study and research.
8	(MSMA108) Linear Algebra (M.Sc. Semester-2)	CO1: Communicate mathematical statements, ideas, results, correct use of mathematical definitions, terminology and symbolism.
		CO2: Demonstrate the understanding and the applications of vector spaces, linear transforms, change of basis, eigenvalues and eigenvectors.
		CO3: Demonstrate the understanding and the applications of diagonalization, various canonical forms and inner product spaces.
		CO4: Apply Gram-Schmidt orthonormalization process and identify various linear operators (Unitary, Adjoint, Hermitian, Skew-Hermitian and Normal) and their applications.
9	(MSMA109) Mathematical Statistics (M.Sc. Semester-1)	CO1: Formulize probability model using various approaches to probability for a given random experiment and skill in R/SPSS for presenting and analyzing the given problem.
		CO2: Analyze a given random situation using concepts of expectation, statistical inequalities, law of large numbers and regression analysis.
		CO3: Implement standard discrete and continuous probability distributions and their applications.
		CO4: Perform large and small sample testing and their applications in real-world problems.
		CO5: Draw inferences about a population from analyzing a sample drawn from that population using estimation and hypothesis testing.
10	(MSMA110) Numerical Analysis (M.Sc. Semester-2)	CO1: Describe a basic understanding of the derivation, analysis, and use of numerical methods, along with an understanding of finite precision arithmetic and the conditioning and stability of the various problems and methods.
		CO2: Identify, develop and apply the appropriate numerical techniques for a problem, interpret the results, and accuracy.
		CO3: Solve systems of linear equations using least squares problems, and other methods.
		CO4: Interpret and solve problems related to interpolation, approximation, and integration of functions.
		CO5: Solve initial values problems, Boundary value problems governed by ordinary differential equations.
11	(MSMA111) Programming Lab-I (M.Sc. Semester-1)	CO1: Apply good programming principles to the design and implementation of C programs.
		CO2: Demonstrate an understanding of primitive data types, values, operators, and expressions in C.
		CO3: Design, implement, debug, and test programs using the fundamental elements of C
		CO4: Design and implement code that includes the reuse of both existing code and calling functions in the C/C++ libraries

		CO5: Describe the procedural and OOPs with concepts of classes, functions, data and objects and demonstrate the use of various OOPs concepts with the help of programs
12	(MSMA112) Programming Lab-II (M.Sc. Semester-2)	CO1: Write loops and decision statements in Python.
		CO2: Design Python functions to facilitate code reuse.
		CO3: Integrate lists, tuples, and dictionaries in Python programs.
		CO4: Apply exception handling in Python applications for error handling.
		CO5: Design object-oriented programs with Python classes.
13	(MSMA114) Fundamentals of Computer (M.Sc. Semester-2)	CO1: Know different operating systems and basic commands
		CO2: Possess the knowledge of programming in C language
		CO3: Write computer programs in MATLAB, Mathematica and SPSS to solve problems.
		CO4: Solve basic computational problems with C language, MATLAB, Mathematica and SPSS.
		CO5: Create good documentation using MS Office tools and Latex.
14	(MSMA201) Functional Analysis (M.Sc. Semester-3)	CO1: Describe how functional analysis uses and unifies the concept of vector spaces and the theory of metric spaces.
		CO2: Explain the normed linear spaces which are not inner product spaces.
		CO3: Describe and apply fundamental theorems for normed linear spaces and Banach spaces such as Hahn-Banach theorem, the open mapping theorem, the closed graph theorems.
		CO4: Differentiate between Banach space and Hilbert space and recognize the basic properties of Hilbert spaces.
		CO5: Describe the fundamentals of spectral theory, and recognize its power in different applications.
15	(MSMA203) Operations Research (M.Sc. Semester-3)	CO1: Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained.
		CO2: Analyze any real life system with limited constraints and depict it in a model form.
		CO3: Determine optimal strategy for Minimization of Cost of shipping of products from source to Destination/ Maximization of profits of shipping products using various methods, Finding initial basic feasible and optimal solution of the Transportation problems
		CO4: Analyze different queuing situations, network scheduling problems and find its optimal solutions using various operational research techniques.
		CO5: Employ the analytical and practical skills in real life acquired during the course.
16	(MSMA204) Dissertation-II (M.Sc. Semester-4)	CO1: Formulate a conceptual project design and conduct experiments using appropriate tools and components.
		CO2: Evaluate the outcomes of the project qualitatively and quantitatively.
		CO3: Apply principles of ethical behaviour, collaborative engagement, socially responsible behavior, and respect for individuals for effective team management.
		CO4: Prepare, and communicate the work in the form of a research article and present the same.
17	(MSMA205) Dissertation-I (M.Sc. Semester-3)	CO1: Identify complex engineering/real-life problems, and explore creative avenues of expression.
		CO2: Compare, contrast, and criticize the existing work for the problem under consideration.
		CO3: Develop a methodology and design strategy to implement the project using appropriate tools and components
		CO4: Acquire, articulate, and convey observations and conclusions using a verbal and non-verbal methods of communication.
18	(MSMA206) Financial Mathematics (M.Sc. Semester-4)	CO1: Describe the financial market and various terminologies used. List the assumptions for mathematical modelling of financial markets. Categorize the types of instruments traded in the financial markets.
		CO2: Compute the risk and return attached with risky and risk free instruments. Pricing of Bonds, Forward, and Future and apply to real problem.
		CO3: Do the option pricing using various models. Effectively compute the volatility and its impact on derivative pricing.
		CO4: Define the stochastic processes, and calculus for forming and solving stochastic differential equations. Apply the Stochastic calculus in option pricing, and other real world and engineering problem.

		CO5: Explain the portfolio and to compute the risk and return attached with it. Construct a multi asset portfolio with minimum risk and maximum return. Use the skill for financial management.
19	(MSMA207) Stochastic process (M.Sc. Semester-3)	CO1: Classify the stochastic process associated with a random phenomena and visualise that using R/SPSS skills.
		CO2: Apply the skill of random walk to analyse suitable physical situation.
		CO3: Analyse Markovian model, both discrete and continuous, and Poisson and birth and death processes.
		CO4: Manipulate a non-Markovian model using appropriate techniques.
		CO5: Model the physical situation for multidisciplinary problems/fields to suitable random process and analyse that for better project management and finance.
20	(MSMA208) Data Mining (M.Sc. Semester-4)	CO1: Identify the scope and necessity of Data Mining for the society.
		CO2: Apply various tools of Data Mining and their techniques on real world problems.
		CO3: Design various algorithms specialized for data mining tasks.
		CO4: Develop further interest in research and design of new Data Mining techniques.
		CO5: Analyze and justify the use of a particular data mining technique for a problem.
		CO6: Compare the various approaches to data warehousing and data mining implementations.
21	(MSMA209) Analysis and Design of Algorithms (M.Sc. Semester-3)	CO1: Design efficient algorithms for real-life problems, using the techniques learned as building block and identify the limitations in algorithm design for solving it.
		CO2: Argue and justify the correctness of algorithm design and analyze the running time of algorithms using asymptotic analysis.
		CO3: Describe different paradigms of algorithm design, such as Divide & Conquer, Greedy, Dynamic Programming, etc, and predict when an algorithmic design situation calls for it.
		CO4: Compare the notion of tractable and intractable problems and develop algorithms for computationally intractable problems.
		CO5: Solve the inter-disciplinary real-world problems including sorting problems, trees and graphs problems, and recurrence relations.
22	(MSMA210) Optimization Techniques (M.Sc. Semester-4)	CO1: Define and use optimization concepts to model the real-world applications as an optimization problem.
		CO2: Apply optimization methods to engineering problems, including developing a model, defining an optimization problem, applying optimization methods, exploring the solution, and interpreting results.
		CO3: Formulate continuous problems into unconstrained and constrained optimization problems on the basis of the conditions provided .
		CO4: Identify computing derivatives methods for direct and adjoint cases.
		CO5: Identify the optimization techniques to determine a robust design for a given real world problem and justify the technique for solving it.
		CO6: Employ basic optimization algorithms in a computational setting and apply existing optimization software packages to solve and analyze the inter- disciplinary real-world problems and for higher study and research.
23	(MSMA211) Number Theory (M.Sc. Semester-3)	CO1: Apply Euclid’s algorithm in divisibility/daily life problems.
		CO2: Solve linear congruence equations. Apply the congruence properties in finding divisibly of a number by 2,3,4 etc. and other daily life problems.
		CO3: Describe various arithmetical functions like Euler phi function and apply these in simplifying various arithmetical problems.
		CO4: Identify the order of an integer modulo n and primitive roots of composite numbers. Describe discrete logarithms.
		CO5: Analyse relation between Quadratic residue and Legendre’s symbols and solve quadratic congruences.
24	(MSMA212) Approximation Theory (M.Sc. Semester-4)	CO1: Describe the concepts and properties of algebraic and trigonometrical polynomials and Bernstein polynomials.
		CO2: Construct various linear positive operators and analyse their approximation properties using different tools.
		CO3: Analyze conditions for convergence of linear positive operators and find order of approximation of functions.
		CO4: Describe error estimates with Jackson’s, Dini-Lipschitz and Stone Weierstrass theorem.

		CO5: Demonstrate the understanding of K-functional and its relationship with modulus of smoothness.
25	(MSMA213) Mathematical Modelling and Simulation (M.Sc. Semester-3)	CO1: Demonstrate an understanding of concepts of modeling and simulation, by extracting the necessary and relevant information regarding the problem.
		CO2: Construct various mathematical models of real world problems and perform their stability analysis.
		CO3: Solve the mathematical models using mathematical techniques and with the help of various techniques.
		CO4: Operate qualitative analysis of the non-linear mathematical models.
		CO5: Analyze and understand the numerical and statistical techniques.
26	(MSMA214) General Relativity and Cosmology (M.Sc. Semester-4)	CO1: Identify the initial step to get a better understanding of different types of tensors and some important mathematical properties of tensors and transformation.
		CO2: Demonstrate an understanding of metric tensor, special theory of relativity and concept of space and time.
		CO3: Explain the general theory of relativity, Einstein field equations.
		CO4: Calculate the Schwarzchild exterior solution and Birkhoff solution.
		CO5: Apply tensor and general relativity to formulate Einstein and De Sitter models in describing the geometry of the universe.
27	(MSMA215) Calculus of Variation (M.Sc. Semester-3)	CO1: Explain the foundations of calculus of variations and its applications in engineering and sciences.
		CO2: Apply the theory and techniques covered in the course to solve variational problems.
		CO3: Discuss the problem on conditional extremum, variation problem of moving boundaries, isoperimetric problem and Sturm Liouville problem; analyse these problems.
		CO4: Describe variational methods such as Rayleigh-Ritz method, Galerkin method, method of Kantorovich, Trefftz method.
		CO5: Derive the Euler-Lagrange equations for variational problems.
		CO6: Illustrate the significance of Hamilton’s principle, principal of least action and Hamiltonian’s canonical equation.
28	(MSMA216) Finite Element Method (M.Sc. Semester-4)	CO1: Apply mathematical thinking and analytic process that involves Variational Formulations.
		CO2: Formulate and solve two point boundary value problems, initial value problems in one dimension.
		CO3: Implement numerical methods (Variational methods) to solve problems related to solid mechanics.
		CO4: Implement the formulation techniques to solve 2-dimensional problems using triangle and quadrilateral elements.
		CO5: Solve complex problems having irregular geometry.
29	(MSMA217) Graph Theory (M.Sc. Semester-3)	CO1: Integrate core theoretical knowledge of graph theory to solve problems.
		CO2: Apply theories and concepts to test and validate intuition and independent mathematical thinking in problem solving.
		CO3: Recognize the applied problems occurring in real world and use the concepts of graph theory to analyse and solve them.
		CO4: Formulate interdisciplinary real-world problems in graph theoretic terms for higher study and research.
30	(MSMA218) Machine Learning (M.Sc. Semester-4)	CO1: Demonstrate an appreciation for what is involved in Learning models from data.
		CO2: Describe a wide variety of learning algorithms including Supervised Learning, Unsupervised Learning, Reinforcement Learning.
		CO3: Evaluate models generated from data using various quantitative and qualitative methods.
		CO4: Apply different learning algorithms to a real problem
		CO5: Present the expected accuracy that can be achieved by applying the models.
	(MSMA222)	CO1: Identify the fundamental concepts and general principles associated with univalent functions in a structured manner to encourage research.
		CO2: Analyze the geometric properties of univalent functions, apply them to interpret related theorems and develop proof techniques.

31	Univalent Function Theory (M.Sc. Semester-4)	CO3: Illustrate the concepts of subordination, provide an extension of real-line inequalities and use it as a tool for problem solving, thus, formulating several complex-inequalities.
		CO4: Demonstrate subclasses of univalent functions characterized by the conditions involving derivatives and investigating the properties of these subclasses.
32	(MSMA223) Cryptography and Coding Theory (M.Sc. Semester-3)	CO1: Classify the various classical encryption techniques.
		CO2: Describe and analyse modern block ciphers.
		CO3: Describe and analyse public key cryptosystems and key exchange algorithms.
		CO4: Construct error correcting codes using various methods, theory and principles.
		CO5: Describe and analyse convolution codes and their decoding.
33	(MSMA224) Fuzzy Sets and Applications (M.Sc. Semester-4)	CO1: Classify “vagueness” and “uncertainty” in the systematic approach.
		CO2: Analyse different applications based on fuzzy model, representing vague knowledge and describe the impact on popular dynamical systems.
		CO3: Appraise decision making in an inter-disciplinary real-world problem within an uncertain environment.
		CO4: Apply relevant software packages to formulate, solve and analyze problems for higher study and research.
		CO5: Design fuzzy-logic based controllers and list their unique characteristics.
		CO6: Apply analytical and practical skills gained during the course to real life and enginnering problems.
34	(MSMA225) Classical Mechanics (M.Sc. Semester-3)	CO1: Classify the central forces from other types of forces and apply it to describe the planetary motion.
		CO2: Describe moment and product of inertia. Explain the basic concepts and underlying principle of the dynamics of rigid bodies.
		CO3: Describe the differential equations and other advanced mathematics in the solution of the problems of dynamical systems.
		CO4: Deduce Lagrange’s and Hamilton’s equation and describe the motion of a mechanical system using Lagrange-Hamilton formalism.
		CO5: Explain generating function and canonical transformation. Describe Hamilton-Jacobi equation of motion.
35	(MSMA220) Advanced Partial Differential Equations (M.Sc. Semester-4)	CO1: Determine the principal theoretical issues concerning the solving of partial differential equations in higher dimensions, classify well posed problems and classical solutions
		CO2: Differentiate between four important linear partial differential equations in R^n-transport equation, Laplace equation, Heat equation and Wave equation, construct representation formula for transport equation, deduce fundamental solution for Laplace equation and representation formula using Green’s functions, apply properties of harmonic functions
		CO3: Define physical significance of heat equation, deduce fundamental solution for heat equation, solve homogeneous and non-homogeneous heat equation in higher dimensions, apply mean-value formula and maximum principle, estimate the solutions of the heat equation
		CO4: Interpret physical significance of wave equation, identify the solution of wave equation in one and higher dimensions, distinguish between d’Alembert’s solution ($n=1$) and solution through spherical means ($n\geq2$), solve non-homogeneous problem using Duhamel’s principle, identify the domain of dependence
		CO5: Analyse general non-linear partial differential equation in higher dimensions, construct representation formulae for nonlinear equations, devise new solutions from envelopes, apply method of characteristics to solve nonlinear equations
36	(MSMA219) Database Management System (M.Sc. Semester-3)	CO1: Describe the fundamental elements of relational database management systems and related concepts.
		CO2: Design ER-models to represent real-life database applications. Explain and apply the concepts to design the relational database from the ER-model and formulate SQL queries for implementation and maintenance of the database.
		CO3: Improve the database design by performing the concept of normalization.
		CO4: Apply basic database storage structures and access techniques like file and page organizations, indexing methods including B tree, and hashing for optimal database organization.
		CO5: Describe and apply the transaction processing and concurrency control techniques.

37	(MSMA202) Measure and Integration (M.Sc. Semester-2)	CO1: Define and identify measurable/non-measurable sets; explain the construction of Borel set and Cantor ternary set.
		CO2: Describe the notion and properties of measurable functions and determine problems related to different kinds of convergence, like convergence in measure, pointwise convergence, almost everywhere convergence and almost everywhere uniform convergence.
		CO3: Describe the main ideas of the proofs for Lusin’s theorem, Frechet theorem and F. Riesz’s theorem on convergence almost everywhere.
		CO4: Construct and compute Lebesgue integrals; describe and apply Lebesgue monotone and dominated convergence theorems and Fatou’s Lemma in solving problems.
		CO5: Analyze Lp spaces and describe their properties.
		CO6: Apply Hölder’s inequality, Minkowski’s inequality and Schwartz’s inequality in solving problems; describe Riesz-Fischer theorem.