NIMS UNIVERSITY

SYLLABUS

OF

MASTER OF SCIENCE (MATHEMATICS) - MSCMTH

VERSION 1.2

DIRECTORATE OF DISTANCE EDUCATION

Shobha Nagar, Jaipur-Delhi Highway (NH-11C), Jaipur- 303121
Rajasthan, India

MSC - MATHEMATICS

Eligibility	:	Graduation in Related Field
Programme Duration	:	2 Years
Programme Objectives	:	This is a Two year full time course aimed to pursue a career in research in mathematical sciences. Besides, there are other career options in corporate houses.
Job Prospects	:	The course has been specifically designed to meet the huge demand for skilled Mathematics Postgraduates in finance and computer science. An external panel from industry has been closely involved in advising on the content and structure of the course. Postgraduates may be employed in a broad range of positions; for instance in research and development teams as part of a large company or in start-ups, as trainee analysts and consultants. Postgraduates may also continue their training in PhD courses, or pursue teaching and education careers

YEAR I

Course Code	Course Title	Theory/ Practical	Continuous Assessment (Internals)	Credits
MTH16104	Topology	70	30	7
MTH16103	Algebra	70	30	7
MTH16102	Partial Differential Equation	70	30	6
MTH16106	Complex Analysis	70	30	6
MTH16105	Differential Geometry	70	30	6
			Total	32

YEAR II

Course Code	Course Title	Theory/ Practical	Continuous Assessment (Internals)	Credits
MTH16207	Fluid Mechanics	70	30	6
MTH16211	Special Functions	70	30	6
MTH16209	Real Analysis	70	30	6
MTH16210	Advance Calculus and Matrix	70	30	7
MTH16208	Mathematical Programming	70	30	6
PRJ16201	Project	200		1
			Total	32

DETAILED SYLLABUS

INSTRUCTIONAL METHOD: Personal Contact Programmes, Lectures (virtual and in-person), Assignments, Labs and Discussions, Learning projects, Industrial Training Programmes and Dissertation.

YEAR I

TOPOLOGY– MTH16104

UNIT	CONTENTS
1	**Metric Spaces & Topological Space:** Introduction to Metric spaces & Topological Space, Metric, Metric & Euclidean Spaces, Bounded and Unbounded Spaces, Spares (or Balls), Accumulation Points, Adherent Points, Interior, Exterior and Boundary of a set, Dense and Non-dense sets, Sequences and sub-sequences in a metric space, Cauchy's sequences, Complete metric spaces, Completeness and contracting mappings, Topological spaces, The product topology & subspace topology, The quotient topology & Metric Topology, Connected spaces, Locally Compact Spaces and Alexandroff, Compactification, Countability & Separation Axioms, Second Countable regular spaces and the Urysohn Metrization theorem, Manifolds.
2	**Algebraic Topology & Classification of Covering Space:** Introduction to Algebraic Topology, Dependence on the base point, Homotopy invariance, The Brouwer fixed point theorem & fundamental theorem of algebra, Categories, Functors & natural transformations, Homotopy categories and homotopy equivalence, The fundamental groupoid, The van Kampen theorem, The unique path lifting property, Covering of groupoids, Group actions and orbit categories, The classification of covering of groupoids, The construction of coverings of spaces, The definition of graphs & Edge paths and trees, The homotopy types of graphs, Covers of graphs and Euler Characteristics, The category of compactly generated spaces
3	**Calibration, Mapping Cylinders, Fibrations and Path Lifting Functions**: The definitions of cofibrations, Mapping cylinders and cofibrations, Replacing maps by cofibrations, A criterion for a map to be a cofibrations, Cofiber homotopy equivalence, The definition of fibrations, Path lifting functions and fibrations, Replacing maps by fibrations, A criterion for a map to be a fibration, Fiber homotopy equivalence, Change of fiber.
4	**Based Monopoly and Homotopy:** Introduction to Based Monopoly and Homotopy, Based homotopy classes of maps, Cones, suspensions, paths loops, Based cofibrations, Cofiber sequences, Based fibrations, Fiber Sequences, Connection between cofiber and fiber sequences, The definition of homotopy groups, Long exact sequences associated to pairs, Long exact sequences associated to fibrations, A few calculations, Change of basepoint, n-Equivalence, weak equivalences and a technical lemma.
5	**CW Complexes Homotopy Excision:** Introduction to CW Complexes Homotopy Excision, The definition and some examples of CW complexes, Some constructions on CW complexes, HELP and the White head theorem, The cellular approximation theorem, Approximation of spaces of CW complexes, Approximations of pairs by CW pairs, Approximation of excessive triads by CW triads, The Homotopy Excision and Freudenthal Theory, Statement of the homotopy excision theorem, The Freudenthal suspension theorem, Proof of the homotopy excision theorem.

LEARNING SOURCE: Self Learning Materials

ADDITIONAL READINGS:

A. General Topology (Hardcover): John L. Kelley

B. General Topology : Mangesh G Murdeshwar; New Age International – 1990

C. Topology: James R. Munkres; Phi Learning - 2009

ALGEBRA – MTH16103

UNIT	CONTENTS
1	**Introduction to Groups-**Binary Operation, Group, Order of an Element, Subgroup, Subgroup Generated by a Set, Cyclic Subgroups and Cyclic Groups, Complex of a Group Congruence Modulo a Subgroup, Cosets, Permutation Groups, Normal Subgroups and Quotient Groups.
2	**Group Homomorphism:** Introduction to Group Homomorphism, Group Homeomorphisms, Automorphisms, Representation Theorems, The Isomorphism Theorems, Corollary, Lemma 11 (Zassenhaus).
3	**Further Topics in Groups:** Definition and Basic Properties, Normalizer of an Element in a Group, Conjugate elements, Corollary, Commutators, Conjugacy and the Class Equation of a Group, Solvable Groups, Subnormal and Normal Series, Maximal Normal Subgroup, Composition Series
4	**Modules:** Introduction to Modules, Module over a Ring, Submodule, The Submodule criterion, Direct Sum, Module Homeomorphisms, Isomorphism Theorems, Generation of Modules, Finitely generated module, Cyclic module.
5	**Field Extensions:** Introduction to Field Extensions, Basic Theory of Field Extensions, Field extensions, Simple field extension, Algebraic field extension, Minimal polynomial of an algebraic element, Splitting Fields, Continuation of an isomorphic mapping, Conjugate elements, F-isomorphism, Normal Extension, Separable and Inseparable Extensions, Separable polynomials, separable elements and separable field extensions.
6	**Linear Transformations on Vector Spaces**: Introduction to Transformations on Vector spaces, Linear Transformations, Nullity and Rank of a Linear Transformation, Algebra of Linear Transformations, Dual Spaces, Second dual of a vector space, Dual Map, Annihilator.
7	**Introduction to Rings and Ideals:** Definition and Basic Properties, Zero divisors, integral domain and field, Characteristic of a ring, integral domain and field, Ideals, Quotient Rings, Euclidean Ring, Prime and Maximal Ideals, Polynomial rings, Zero of a polynomial, Polynomial ring for several variables.
8	**Euclidean Rings:** Introduction to Euclidean rings, Euclidean Ring, Division in Commutative Rings, Units and Associates, Prime Elements, Unique Factorization Domain.
9	**Vector Spaces:** Vector Space, Vector Subspace, The subspace criterion, Subspace generated by a set, Linear combination of vectors, Linear Dependence, Independence and Basis, Spanning set, Basis of a vector space, Quotient Space.

LEARNING SOURCE: Self Learning Materials

ADDITIONAL READINGS:

A. Topics in Algebra, 2nd Ed. : I N Herstein; John Wiley & Sons, 2006.

PARTIAL DIFFERENTIAL EQUATIONS – MTH16102

UNIT	CONTENTS
1	**Differential Equations:** Introduction to Differential Equations, Charpit method, Jacobi's method, Monge's method of type (Rs+Ss+Tt=V).
2	**Partial Differential Equations of Second Order:** Introduction to Partial Differential Equations of Second Order, Linear Homogeneous Partial Differential Equation with Constant Coefficients, Rule for finding the Complementary Function (C.F.),Non-Homogeneous Linear Partial Differential Equations with Constant Coefficients, Equations Reducible to Linear Partial Differential Equations with Constant Coefficient, Solution of Linear Partial Differential Equation.
3	**Elliptic Differential Equations:** Introduction to Elliptic Differential Equations, Product Method: Solution of Boundary Value – Problems by the method of separation of variables, Laplace equations, Poisson equations, Harmonic function, Maximum-Minimum Principle, Laplace equation in terms of Polar Coordinates, Laplace equation in spherical coordinates, Solution of Two-Dimensional Laplace Equation in Plane Polar Coordinate (r,θ).
4	**Parabolic Differential Equations:** Introduction to Parabolic Differential Equations, One Dimensional Heat Equation, Two Dimensional Heat Equation, Three Dimensional Heat Equation, Solution of Heat Equation in Cylindrical Coordinates, Uniqueness of the Solution and Maximum-Minimum Principle, Uniqueness Theorem.
5	**Hyperbolic Differential Equations:** Introduction to Hyperbolic Differential Equations, Forms of Wave Equation, Derivation of One Dimensional Wave Equation, Derivation of Two Dimensional Wave Equation, D'alembert's solution of Wave Equation, Forced vibration: Solution of Non-Homeogeneous Equation, Method of Eigen Function, Vibration of a Circular Membrane, Uniqueness of the solution for The Wave Equation, Uniqueness Theorem, Duhamel's Principle.

LEARNING SOURCE: Self Learning Materials

ADDITIONAL READINGS:

A. Partial Differential Equations: Lawrence C. Evans; American Mathematical Soc.; 2010.

B. Introduction to Partial Differential Equations 2nd Ed.: Rao Sankara, PHI Learning Pvt. Ltd. 2006.

COMPLEX ANALYSIS – MTH16106

UNIT	CONTENTS
1	**Analytic Function:** Introduction to Analytic Function, Equation of Circle in Complex Plane, The Spherical Representation of Complex Numbers and Stereographic Projection, Analytic Function, Analytic, Holomorphic and regular function, Polar Form of Cauchy-Riemann Equations, Orthogonal System, Harmonic Function, Multiple Valued Functions, Branches.
2	**Conformal Mapping:** Introduction to Conformal Mapping, Resultant or Product of Two Bilinear Transformations, The Linear Group, Equation of a Circle through three given points, Cross Ration, Preservance of Cross-Ration under Bilinear Transformation, Two Important Families of Circles, Mapping of transformation, Conformal mapping, Some elementary transformation, Elliptic, Hyperbolic and Parabolic transformation.
3	**Sequences & Power Series:** Introduction to Sequences and Power Series, Convergent Sequences, Cauchy Sequence, Sequence and Series of Functions, Principle of Uniform Convergence of a Sequence, Cauchy's criterion for series, Trigonometric and hyperbolic functions, Power series, Elementary Transcendental Functions, Logarithmic & Inverse trigonometric function.
4	**Complex Integration:** Introduction to Complex Integration, Cauchy's Fundamental Theorem, Cauchy Integral formula, Derivative of an analytic function, Poisson's Integral Formula for a Circle, Morera's Theorem, Fundamental Theorem of Integral Calculus for Complex Functions, Taylor's Theorem, Laurent's Theorem, Uniqueness theorem, The Zeros of an Analytic Function, Singularities of an Analytic Function, Polynomials, Characterization of Polynomials.
5	**Uniform Convergence:** Introduction to Uniform Convergence, General Principle of Uniform Convergence, Uniform convergence of a series, Continuity of the Sum Function of a Series, Hurwitz theorem, Uniform convergence of power series, Infinite Products, General Principle of Convergence of an Infinite Product, Three Important Theorems on Infinite Products, Uniform Convergence of Infinite Product

LEARNING SOURCE: Self Learning Materials

ADDITIONAL READINGS:

A. Complex Analysis : An Introduction to the Theory of Analytic Functions of One complex Variable : Lars Valerian Ahlfors; McGraw-Hill, 1979.

B. Krishna's Complex Analysis: A R Vasishtha; KRISHNA Prakashan Media (P) Ltd.

DIFFERENTIAL GEOMETRY – MTH16105

UNIT	CONTENTS
1	**Envelopes and Rules Surfaces:** Introduction to Envelopes and Rules Surfaces, Characteristic of a Family of Surface, Envelope of a Two- Parameter Family of Surfaces, Ruled Surfaces, Equation of a ruled surfaces, Developable surfaces, Developable associated with Space Curves, Tangent, Principal normal and Binormal Surfaces, Skew-Surfaces.
2	**Asymptotic lines, Fundamental Equations of Surface Theory and Geodesics:** Introduction, Asymptotic Lines, Fundamental Equations of Surface Theory, Asymptotic Lines, Curvature and Torsion of an Asymptotic Line, Beltrami-Enneper Theorem, Gauss's formulae, Parallel Surfaces, Bonnet's Theorem, Geodesics, Geodesics Curvature and Torsion of a Geodesics, Joachimsthal Theorems.
3	**Curves on Surfaces (Fundamental Forms, Curvature of Surface and Lines of Curvature):** Introduction, Surface, Parametric Transformation, Tangent plane and normal line, Fundamental Forms and Fundamental Magnitudes, Family of Curves, Curvature of surfaces, Lines of Curvature, Lines of curvature of some surfaces, Dupin's Indicatrix.
4	**Surfaces in General:** Introduction, Conoids, Tangents & Tangent Plane, Singular, Double, Triple Tangent Plane, Cylindroids, Biplanar Node & Uniplanar Node.
5	**Curves in Space:** Introduction, Space Curves, The Tangent Line, Class of a vector valued function, Fundamental unit Vectors and Fundamental Planes, Rectifying Plane, Curvature & Torsion, Serrect- Frenet Formulae, Spherical Indicatrix, Osculating Circle and Osculating Sphere, Fundamental Theorem on Space Curves, Intrinsic Equations, Bertrand Curves, Involutes and Evolutes.

LEARNING SOURCE: Self Learning Materials

ADDITIONAL READINGS:

A. Differential Geometry: Erwin Kreyszig, Dover, 1959

B. Differential Geometry (Coordinate Geometry of Three Dimensions); SC Mittal, DC Agarwal, KRISHNA Prakashan Media (P) Ltd.

YEAR II

FLUID MECHANICS– MTH16207

UNIT	CONTENTS
1	**Irrotational Motion:** Velocity Potential due to a source, Velocity Potential due to a Doublet, AXT-Symmetric flows - Stroke's Stream function, Transformation of Source and Doublet, Kutta – Joukowski's Theorem.
2	**Equations of Motion:** Euler's Dynamical Equations, Conservative field of force, Integration of the Equations of Motion, Bernoulli's Theorem, Helmholtz Theorem, Lagrange's Equations of Motion, Cauchy's Integrals, Principle of Energy for Incompressible Fluids.
3	**Kinematics:** Introduction, Viscosity, Real Fluids, The Material Derivative (also called Subtantial Derivative), Stream line, Difference between the Stream Lines and Path Lines, Velocity Potential, Surfaces orthogonal to stream lines, Equation of continuity, Boundary surface.
4	**Vortex Motion:** Vorticity and its component, Definitions- Vortex Line, Vortex Tube and Vortex Filament, Rectilinear Vortices, Centre of Vortices, Vortex Filament, Vortex inside an infinite circular cylinder, Four Vortices, Karman Vortex Street, Vortex Sheets.
5	**Waves:** Equation governing wave motion, Standing or stationary waves, Two Types of Liquid Waves, Energy of progressive wave, Waves at the common surface of two liquids, Group Velocity, Energy of long wave, General equation of long wave, Long Waves – case of steady motion, .

LEARNING SOURCE: Self Learning Materials

ADDITIONAL READINGS:

A. Advances in Mathematical Fluid Mechanics: Rolf Rannacher, Adelia Sequeira, Springer.

SPECIAL FUNCTIONS – MTH16211

UNIT	CONTENTS
1	**Factorial, Gamma and Beta Functions:** Introduction, Definitions, Theory, Factorial function, Gamma function, Digamma function, Incomplete Gamma function, Beta function B, Incomplete Beta function B_x.
2	**Error and Complementary Error Functions**: Introduction, Historical Perspective, Definitions & Theory of Gaussian function, Error function, Complementary Error function, Inverse Error function, Relations and Selected Values of Error Functions, Derivatives of the Error Function, Repeated Integrals of the Complementary Error Function, Numerical Computation of Error Functions, Rational Approximations of Error Functions, Chebyshev Polynomials.

3	**Elliptic Integrals, Elliptic Functions and Theta Functions:** Introduction, Historical Perspective, Elliptic Integral, Elliptic Function, Theta Function.
4	**Bessel Functions of the First and Second Kind:** Introduction, Bessel Equation, Bessel Functions, Modified Bessel Equation, Modified Bessel Functions, Kelvin's Functions, Relations satisfied by the Bessel function, Roots of Bessel Functions, Modified Bessel Functions, Hankel Functions, Orthogonality of Bessel Functions.
5	**Legendre Polynomials and Functions :** Introduction, Legendre's Equation and Legendre Functions, Legendre's associated differential Equation, Orthogonality of Legendre Polynomials.
6	**Chebyshev Polynomials :** Introduction to Chebyshev Polynomials, Maximum Values, Composition, Zeros, Recurrence Relation, Differential Equation and its Solution, Chebyshev Polynomials Over a Discrete Set of Points, Additional Identities of Chebyshev Polynomials, The Shifted Chebyshev Polynomials, Approximation of Functions by Chebyshev Polynomials.
7	**Hypergeometric Functions:** Introduction to Hypergeometric Functions, Recurrence relations, Integral representation, Integral Representation, Generating Function, Relation to other functions, Differential Equation, Integral Representations, Other Definitions Hypergeometric and Functions.

LEARNING SOURCE: Self Learning Materials

ADDITIONAL READINGS:

A. Special Functions and Their Applications: NN Lebedev, Dover Publications;

REAL ANALYSIS – MTH16209

UNIT	CONTENTS
1	**Riemann Integral or Inproper Integral:** Introduction and Definition of the Integral, Existence of the Integral, Properties of the Integral, Improper Integrals, Existence of the proper Riemann Integral.
2	**Sequences and Series:** Introduction to Sequences and Series, Sequence of real numbers, Real topics revisited with sequences, Infinite series of constants, Sequence and series of functions, Power series.
3	**Structure 9^{th} and Functions of Several Variable:** Introduction to Structure 9^{th} and Functions of Several Variable, Structure of R^n, Continuous real – valued functions of n variables, Partial derivatives and the differential, The Chain rule and Taylor's theorem.
4	**Liner Transformation and Matrices:** Linear Transformations and Matrices, Continuity and Differentiability of Transformations, The Inverse function theorem, The Implicit function theorem.
5	**Multiple Integrals:** Introduction to Multiple Integrals, Definition and Existence of the Multiple Integral, Iterated Integrals and Multiple Integrals, Change of variables in Multiple Integrals.

LEARNING SOURCE: Self Learning Materials

ADDITIONAL READINGS:

A. Real Analysis: V Karunakaran, Dorling Kindersley (India) Pvt. Ltd., 2012.

B. Understanding Real Analysis: Paul Zorn; Taylor & Francis Group 2010.

ADVANCE CALCULUS AND MATRIX – MTH16210

UNIT	CONTENTS
1	**Differentiation:** Differentiation of implicit function, Parametric functions and their differentiation, Differentiation by Transformation, Differentiation of a function with respect to another function, Successive differentiation : Higher order differentiation, nth differential coefficient of functions (Standard Results), Application of partial fraction for finding nth derivative application of De moivre's theorem for finding nth derivative, Trigonometric transformations, nth derivative of a product of two function (Leibnitz's Theorem)
2	**Expansion of Functions**: Maclaurin's theorem, Taylor's Theorem, Partial differentiations, Homogeneous function, Euler's theorem on homogeneous functions, Total differential coefficient, Change of variables.
3	**Integration:** Integration by partial fraction, Integration of rational and irrational algebraic functions, Integration of transcendental function, Definite integral, Evaluation of definite integral by substitution, General Properties of Definite integral, Definite integral as the limit of a sum, Application of definite integral to find the sum of infinite series.
4	**Differential Equations:** First order linear differential equations, Exact differential equations, First order and higher degree differential equation, Clairaut's Equation, Linear Differential Equation of order n, Homogeneous equations of second order with constant coefficients, Non-Homogeneous equation of second order with constant coefficients.
5	**Matrices:** Minors and cofactors, Expansion of a determinants, Application of determinants, Adjoint of a square matrix, Inverse of a matrix, Elementary operations on matrices, Echelon form of a matrix, Solution of system of linear equations by matrix method, Solution of system of linear equations by elementary transformation (Operations), Submatrix of a matrix, Rank of a matrix, normal form of a matrix (Canonical form), Solution of system of non-homogenous linear equations using rank, System of homogeneous linear equations and their solutions using rank, Vectors and their linear dependence characteristic roots and vectors (Eigen values and Eigen vectors), Cayley Hamilton theorem, Application of Cayley-Hamilton theorem to find the inverse of a non-singular matrix.

LEARNING SOURCE: Self Learning Materials

ADDITIONAL READINGS:

A. Advanced Calculus: Devi Prasad, PHI Learning Private Limited, New Delhi; 2009.

B. Theory of Matrices : B S Vatsa; New Age International (P) Ltd. 2005.

MATHEMATICAL PROGRAMMING – MTH16208

UNIT	CONTENTS
1	**Mathematical Programming An Overview:** An introduction to Management Science, Model Classification, Formulation of some examples, A Geometrical Preview, A Classification of Mathematical Programming Models.
2	**Solving Linear Programs:** Simplex Method—A Preview, Reduction to Canonical Form, Simplex Method—A Full Example, Formal Procedure, Transition From Phase I To Phase II, Linear Programs with Bounded Variables.
3	**Sensitivity Analysis:** An example for Analysis, Shadow Prices, Reduced Costs, and New Activities, Variations in the Objective Coefficients, Variations in the Right-hand-side Values, Alternative Optimal Solutions and Shadow Prices, The Computer Output—An Example, Simultaneous Variations within the Ranges, Parametric Programming.
4	**Duality in Linear Programming:** A preview of Duality, Definition of the Dual Problem, Finding the dual in general, The fundamental duality properties, Complementary slackness, The dual simplex method, Primal-dual algorithms, Mathematical Economics, Game theory
5	**Mathematical Programming in Practice:** The Decision-making Process, Stages of Formulation, Solution, and Implementation, The role of the computer, A simple example.
6	**Integration of Strategic and Tactical Planning in the Aluminum Industry:** The Planning Approach, The Aluminum Industry and Smelter Operations, Overview of the Strategic Planning Model, Mathematical Formulation of the Strategic Planning Model, The Tactical Planning Model, Mathematical Formulation of the Tactical Planning Model.
7	**Planning the Mission and Composition of the U.S. Merchant Marine Fleet:** Structure of the Problem, The Linear-Programming Model, Mathematical Description of the Model, Basic findings, Sensitivity Analysis.
8	**Network Models:** The General Network-Flow Problem, Special Network Models, The Critical-path Method, Capacitated Production - A hidden network, Solving the Transportation problem, Additional Transportation considerations, The Simplex method for Networks, Solving the minimum-cost flow problem.

LEARNING SOURCE: Self Learning Materials

ADDITIONAL READINGS:

A. Mathematical Programming (Theory and Methods): S M Sinha, Reed Elsevier India Pvt. Ltd, 2006.

B. Mathematical Programming: Steven Vajda; Dover Publications 2009.