NORTH MAHARASHTRA UNIVERSITY, JALGAON.

Revised syllabus for
M.Sc. (Mathematics)

(For affiliated colleges only)

With effect from Academic year 2017-18 (First year) & 2018-19 (Second year)

NORTH MAHARASHTRA UNIVERSITY, JALGAON

M.Sc. Mathematics

Revised Syllabus

(With effect from Academic year 2017-18 (First year) & 2018-19 (Second year))

A) ELIGIBILITY

A candidate who has passed B.Sc. with Mathematics as a principal subject or any graduate with Mathematics as one of the subject at S. Y. B. Sc. with a minimum of 50% marks in mathematics shall be eligible for admission to the year M.Sc. Mathematics, preference should be given to B. Sc. (Mathematics Principal) students.

B) STRUCTURE

The structure of M.Sc. Mathematics will be as under:

Semester	Subject code	Subject Title
I	MT 101	Advanced Real Analysis
	MT 102	Topology
	MT 103	Abstract Algebra
	MT 104	Ordinary and Partial Differential Equations
	Any one of the following	
	MT 105	Theory of Fuzzy sets
	MT 106	Programming in C++
II	MT 201	General Measure Theory
	MT 202	Complex Variables
	MT 203	Linear Algebra
	MT 204	Mathematical Methods
	Any one of the following	
	MT 205	Number Theory
	MT 206	Classical Mechanics
III	MT 301	Topics in Functional Analysis
	MT 302	Statistical Techniques
	MT 303	Topics in Field Theory
	Any two of the following	
	MT 304	Fluid Dynamics
	MT 305	Difference Equations
	MT 306	Theory of Lattices
	MT 307	Elements of Graph Theory
IV	MT 401	Advanced Mathematical Methods
	MT 402	Operations Research
	MT 403	Commutative Algebra
	Any two of the following	
	MT 404	Advanced Abstract Algebra
	MT 405	Advanced Numerical Methods
	MT 406	Algebraic Topology
	MT 407	Linear Integral Equations

Note:

A) There shall be 60 contact hours per theory course per semester out of which 48 hours are reserved for teaching and 12 hours test, tutorials, orals and seminars.

B) Regular attendance, Seminar, oral, Behavior and internal test shall be considering for 40 marks as an internal assessment.

C) EXAMINATION

1) There shall be University examination of 60 marks for each course at the end of each semester.
2) The University examination will be of 3 hours duration for each course.

D) STANDARD OF PASSING

1) The candidate who has secured at least 24 marks out of 60 in the university examination and at least 16 marks out of 40 shall be declared to have passed in the paper.
2) The candidate failing to secure at least 24 marks out of 60 in the University examination can reappear for subsequent university examination.
3) The candidate having the backlog of subjects (s) can be admitted to the second year of M.Sc.

E) Award of class, university terms etc., will be as per the existing University norms.

SEMESTER I:

MT-101: Advanced Real Analysis

1. Countable and uncountable sets, Infinite sets and the axioms of choice, Cardinal numbers and their arithmetic, Schroeder- Bernstein theorem, Cantors theorem and the continuum Hypothesis, Zorn's lemma, Well Ordering principle, Cantor set, Cantor like sets, The Lebesgue functions. **(8 Hours)**

2. Measure on the real line: Lebesgue Outer measure, Measurable sets, Regularity, Measurable functions, Borel sets and Lebesgue measurability. **(17 Hours)**

3. Integration of functions of a real variable: Integration of nonnegative function, The general integral, Integration of series, Riemann and Lebesgue integrals**.** **(15 Hours)**

4. Differentiation: The four derivatives. Functions of bounded variation. Lebesgue differentiation theorem, Differentiation and Integration**.** **(10 Hours)**

5. Differentiation of monotone function: Vitali covering theorem (lemma), Fundamental theorem for integral calculus for Lebesgue integral, Absolutely continuous functions. **(10 Hours)**

Recommended Books:

1) G. de Barra, Measure Theory and Integration. New Age International (p) Limited, New Delhi, 2000. **(Chapter 1. Art 1.5,1.7, Chapter 2. Art 2.1,2.5, Chapter 3 Art 3.1 to 3.4 Chapter 4 Art 4.1, 4.3 to 4.5 Chapter 9 Art 9.3)**

2) Royden H. L., Real analysis, Prentice-Hall of India (P) Limited, New Delhi, 4th Edition, 2009.**(Chapter Art-1)**

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MT 102: Topology

1. Topological spaces and continuous functions: Topological spaces, Basis for topology. The order topology, subspace topology, closed sets and limit points, continuous functions, The product topology, Continuous functions, Metric topology, The quotient topology. **(20 Hours)**

2. Connectedness and compactness: Connected spaces, connected sets in the real line, components and path components, local connectedness compact spaces, Limit point compactness. **(20 Hours)**

3. Countability and separation axioms: The countability axioms, The separation axioms, The Urysohn Lemma, Urysohn Metrization theorem. **(12 Hours)**

4. The Tychonoff Theorem, Completely regular spaces. **(8 Hours)**

Recommended books:

1) J.R. Munkers, Topology: A First Course, Prentice Hall of India Ltd., 1992.
(Chapter2, sec 2.1 – 2.9 and 2.11; Chapter 3, sec 3.1 -3.8; Chapter 4, sec 4.1-4.4 and Chapter5, sec 5.1-5.2).

2) K.D. Joshi, Introduction to general topology, Wiley Eastern India Ltd, Reprint 2004.

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MT-103: Abstract Algebra

1. Direct product of subgroups, Class equation, Cauchy's Theorem, Solvable groups, Sylow's Theorem, Jordan - Holder Theorem. **(30 Hours)**

2. Factorization, Euclidean domains, principal ideal domains, Unique Factorization domains, Polynomial rings, Roots of polynomials, factorization of polynomials. (**20 Hours**)

3. Noetherian rings, Hilbert basis Theorem. (**10 Hours**)

Recommended Books:

1) N.S. Gopalkrishnan: *University Algebra*, Wiley – Eastern, 1988.
   (Sec. 1.10, 1.12, 1.13, 1.14, Sec. 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16)
2) N.S. Gopalkrishnan: *Commutative Algebra*, Oxonian press pvt. Ltd., New Delhi, 1988.
   (Sec. 3.1)

Reference Books:

1) I.N. Herstein: *Topics in Algebra*, Wiley – Eastern, 1988.
2) N. Jacobson: *Basic Algebra*, Vol. I-2009
3) J.B. Freleigh: *Abstract Algebra.*
4) Jain and Bhattacharya: *Basic Abstract Algebra.1994 Cambridge Press.*

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MT-104: Ordinary and Partial Differential Equations

1. Second Order L.D.E. with constant Coefficients: Basic theory of linear differential equations (L.D.E), the homogeneous and non-homogeneous L.D.E. with constant coefficients; finding C.F. and P.I. the method of undermined coefficients, Variation of Parameters, The Cauchy-Euler equation; Theorems on second order homogeneous L.D.E. **(12 Hours)**

2. Linear PDE order one: Introduction, origin, derivation of PDE by removing arbitrary constant and function; Lagrange's method of solving $Pp + Qq = R$; Type-I, II, III, IV for solving $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$; Integral surfaces passing through a given curve. **(12 Hours)**

3. Non-Linear PDE of order one : Complete integral, P.I., singular integral, general integral for PDE of first order; general method for solving PDE of order one and any degree, Charpit's method; Standard form when p and q are present. Clairaut's equation $z = px + qy + f(p, q)$; standard form when only p, q and z are present; Jacobi's method. **(12 Hours)**

4. Linear PDE with constant coefficients: Homogeneous and non-homogeneous linear PDE with constant coefficients. Methods of finding C.F. and P.I. for non-homogeneous. Linear PDE. **(12 Hours)**

5. PDE with variable coefficients: Introduction to PDE with variable coefficients and various types of solution; Laplace transformation, canonical forms, linear parabolic, hyperbolic and elliptic equations. Monge's method of integrating PDE. **(12 Hours)**

Recommended books:

1) Shepley L Ross: Differential Equations,3rd Edition 2010, John Wiley and sons, New York.
2) Roy Singhania: Advanced differential equations 1995, S. Chand Publication
3) Ian Sneddon: Elements of Partial differential equations. Mcgraw Hill 1957 New York.

Reference Books:

1) E.A. Coddington: Introduction to ordinary differential equations, 1961 Prentice Hall of India.
2) T. Amarnath: An elementary course in partial differential equations, Narosa Publishing house.

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MT-105: Theory of Fuzzy sets

1. Fuzzy set theory: Introduction, Fuzzy versus Crisp, Fuzzy sets: Definition, different types, fuzzy set basic concepts, α-cuts and their properties, decomposition theorems. **(10 Hours)**

2. Operations on Fuzzy sets: Extension principle for fuzzy sets, fuzzy compliments, t-norms and t-conorms, Definition of intersection and union by Hamacher, Yager's union and intersection of two fuzzy sets, intersection and union of two fuzzy sets as defined by Dubois and Prade, Combination of operations, Aggregation operations. **(15 Hours)**

3. Fuzzy numbers and arithmetic: Introduction, Fuzzy numbers, Interval analysis, Fuzzy Arithmetic, Arithmetic operations on fuzzy numbers, lattice of fuzzy numbers. **(10 Hours)**

4. Fuzzy relations: Introduction, Projections and cylindrical fuzzy relations, Composition, properties of Min-max composition, binary relations and their compositions, compatibility relation, Fuzzy equivalence relations, fuzzy ordering relation, Fuzzy morphisms. **(15 Hours)**

5. Fuzzy logic: Fuzzy propositions, fuzzy quantifiers, Fuzzy hedges, Fuzzy implications, Inference from conditional fuzzy propositions. Generalization of hypothetical syllogism, Inference from conditional and qualified propositions. **(10 Hours)**

Recommended books:

1) G.J. Klir and B Yuan: Fuzzy sets and fuzzy logic, Prentice Hall of India Ltd. New Delhi 1997. **(Sec. 1.1-1.5, Sec. 2.1 – 2.3, Sec. 3.1-3.6, Sec. 5.1-5.8, Sec. 8.3-8.8)**

Reference Books:

1) H. J. Zimmermann: Fuzzy Set Theory and its Applications, Allied Publishers Ltd. New Delhi 1991.

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MT-106: Programming in C++

1. Elementary Concepts: Introduction, output operator, characters, literals, variables and declaration, program token, initializing variables and constants, input operator and output operator, simple programs. **(8 Hours)**

2. Fundamental Types: Numeric, Boolean, enumeration, character, integer, arithmetic, increment, decrement, and composite assignment operators. Floating point, type conversion, numeric outflow, round-off error, and the e-format. **(8 Hours)**

3. Conditional statements: If and If-Else statements, statement blocks, compound conditions, short-circuiting, Boolean expressions, nested selection, else-if, switch statements and conditional expression operators. **(8 Hours)**

4. Iteration: The while statement, terminating a loop, do-while, for statements, break, continue and go-to Statements. **(8 Hours)**

5. Functions: Standard library functions, user defined functions, test drivers, functional declarations, local variables and functions, void functions, Boolean functions, Input- Output functions, passing by reference, passing by constant reference, inline function, slope, over loading, main function, default arguments. **(8 Hours)**

6. Arrays: Processing and initialization of arrays, array index, passing an array to a function, linear search, bubble sort, binary search algorithms, arrays with enumerations types, type definitions, multi-dimensional arrays. **(10 Hours)**

7. Numerical methods and programs: Finite differences, operators, and Interpolation by Central differences Laggrange and Hermite interpolation polynomials, numerical solution of first order differential equations by modified Euler's method and fourth order R-K method. Numerical problems and simple programs to Evaluate the above methods. **(10 Hours)**

Recommended Books:

1) John R. Hubbard: *Programming with C++*, Schaum's outline series, 2002.
2) V.N. Vedamurthy and N.Ch.S.N. Iyengar: *Numerical methods,* Vikas Publishing House.2008

Reference Books:

1) Deital H.M. and Deital P.J: *C++ How to program*, Prentice Hall of India, 1998.
2) Capper, D.M.: *Introducing C++ for Scientists*, Engineers and Mathematicians, Springer-Verlag, 1994.

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SEMESTER II:

MT-201: General Measure Theory

1. Abstract Measure Space: Measures and outer measure, Extension of a measure, Uniqueness of extension, Completion of a measure, Measure spaces, Integration w.r.t. a measure. **(15 Hours)**

2. Integration and L_p-spaces: The L_p-spaces, Convex functions, Jensen's inequality, the inequalities of Holders and Minkowski. Completeness of L_p (μ) (Reisz Fisher Theorem) **(10 Hours)**

3. Convergence: Convergence in measure, almost uniform convergence, Egoroffs theorem, Lusin's theorem, Convergence diagram, Counter examples. **(10 Hours)**

4. Signed measure and their derivatives: Signed measures and The Hahn Decomposition, The Jordan Decomposition, The Radon-Nikodym theorem, Some applications of the radon theorem, bounded linear functional on L_p. **(15 Hours)**

5. Measure and integration in a product spaces: Measurability in a product spaces, The product measure and Fubini's theorem, Lebesgue measure in Euclidean space. **(10 Hours)**

Recommended books:

1) G. de Barra, Measure theory and Integration, 4th Edition 2000, New Age International Ltd. **(Chapter 5 Art 5.1 to 5.6 Chapter 6 Art 6.1 to 6.5, Chapter 8 Art 8.1 to 8.5 Chapter 10 Art 10.1 to 10.3)**
2) Royden H. L., Real analysis 4th edition 2009, prentice – Hall of India (P) Ltd New Delhi. **(Chapter 3 - Art 6 , Chapter 4 - Art 5).**

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MT-202: Complex Analysis

1. Power series, Analytic functions, Branch of a logarithm, Mobius (Bilinear) Transformations and Conformal Mappings. **(10 Hours)**

2. Riemann-Stieltjes Integrals, Power Series representation of analytic functions, Taylor's Theorem, Cauchy's Estimate, Zeros of an analytic function, Liouville's theorem, Fundamental Theorem of Algebra, Maximum Modulus Theorem. **(15 Hours)**

3. Index of a closed curve, Cauchy's theorem, Cauchy's Integral Formula, Higher Order derivatives, Morera's Theorem, The Homotopic version of Cauchy's Theorem and simple connectivity, Counting of Zeros, The Open mapping theorem, Goursat's theorem. **(10 Hours)**

4. Singularities, Classification of Singularities, Laurent's series, Casorati-Weierstrass theorem, Residues, Cauchy's residue theorem, Evaluation of integrals, Meromorphic functions, The Argument principle, Rouche' theorem, Schwartz lemma. **(15 Hours)**

5. Convex functions and Hadamard's three circles theorem, The space of continuous functions, Spaces of analytic functions, The Riemann mapping theorem. **(10 Hours)**

Recommended Book:

1) J. B. Conway: *Functions of One Complex variable*,1995 Springer International Student Edition.

Reference Books:

1) S. Ponnusammy and Herb Silverman: *Complex Variables with Applications*, Birkhauser.2006
2) S. Ponnusammy: *Foundations of Complex Analysis*, 2nd edition Alpha, Narosa Publishing House.

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MT-203: Linear Algebra

1. Modules, Submodules, R-homomorphism, Isomorphism, Direct sum of modules, free modules, Rank, Structure theorem for finitely generated modules over PID, Application to group Theorem. **(36 Hours)**

2. Jordan and Rational canonical forms. (**16 Hours**)

3. Localization of rings, Local rings and modules, Noetherian modules, Primary decomposition for modules. **(8 Hours**)

Recommended Books:

1) N.S. Gopalkrishnan: *University Algebra*, Wiley – Eastern, 1988.
   (Sec. 3.6, 3.7, Sec. 5.10)
2) C.S. Musli: *Introduction to Rings & Modules*. Cambridge University 2001
   (Sec. 2.1, 2.2, 2.3, 3.2)

Reference Books:

1) I.N. Herstein: *Topics in Algebra*, Wiley – Eastern, 1988.

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MT-204: Mathematical Methods

1. Linear boundary value problems: Introduction, derivation of wave equation, heat equation and Laplace's equation in Cartesian, cylindrical and spherical co-ordinates. Principle of superposition, series solutions, separation of variables, types of initial value problems and general solution of partial differential equation. **(15 Hours)**

2. Orthogonality: Orthogonality of sets of functions in the space of piecewise continuous functions on (a,b) generalized Fourier Series, approximation in the mean, closed and complete orthonormal sets. Fourier series and half range Fourier series, Sturm-Liouville problems, orthogonality of the eigen functions and their uniqueness. **(15 Hours)**

3. Boundary value problems: Boundary value problems involving the wave equation, heat equation and Dirichlet's problems. Solution by the method of separation of variables, temperature in a long Cylinder, heat transfer at the surface of the cylinder and vibrations of the circular membrane. **(15 Hours)**

4. Bessel's functions: Bessel's differential equation and its solution, Bessel function of first kind, second kind, Bessel functions of order zero and one, recurrence relations, generating function, orthogonality of Bessel functions, Fourier Bessel Series. **(15 Hours)**

Recommended Books:

1) R.V. Churchill and J.W. Brown: Fourier series and Boundary value problems, 2011 McGraw-Hill International.
2) J. P. Chauhan : Differntial and difference equations, Garg Publishing House.
3) Roy Singhania : Advanced Differential Equations.1988, S Chand Pub.

Reference Books:

1) Mary, L Boas: methods of Mathematical Physics.
2) N. N. Lebedev : Special functions and their applications, Prentice Hall.

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MT-205: Number Theory

1. Arithmetic functions: The Mobius function $\mu(n)$, The Euler totient function $\phi(n)$, Dirichlet product of arithmetic functions, Dirichlet inverses and the Mobius inversion formula. The Mangolt function $\Lambda(n)$, Multiplicative functions, Dirichlet multiplication, The inverse of a completely, multiplicative function, Liouvilles function $\lambda(n)$, The divisor function $\sigma(n)$, Generalized convolutions. Formal power series, Bell series of an arithmetical function, Bell series and Dirichlet multiplication, Derivatives of arithmetical functions, The Selberg identity. **(20 Hours)**

2. Congruences: Residue classes, Complete and reduced residue systems and Euler-Fermat's theorem, Polynomial congruences $mod\ p$. Lagranges theorem and its applications, Polynomial congruences with prime power moduli. The principle of cross classification. **(12 Hours)**

3. Quadratic residues and Quadratic Reciprocity law: Quadratic residues, Legenre's symbol and its properties, Evaluation of $(-1|\ p)$ and $(2\ |\ p)$, Gauss lemma, The Quadratic Reciprocity law and its applications, The Jacobi Symbol. Applications to Diophantine equations. **(14 Hours)**

4. Primitive roots: The exponent of a number modulo m, Primitive roots, Primitive roots and reduced residue systems, The non-existence of primitive roots $mod\ p^n$ and p^{2n} for odd primes p

and $n \geq 1$. The non-existence of primitive roots in the remaining cases. The number of primitive roots $mod\ m$. the primitive roots and quadratic residues. The index calculus. **(14 Hours)**

Recommended Book:

1) T. M. Apostol: *Introduction to Analytic Number Theory*, 1972 Springer International student Edition. **(Sec. 2.1 - 2.19, Sec. 5.2, 5.4, 5.5, 5.6, 5.9, 5.10, Sec. 9.1 to 9.8, Sec. 10.1 to 10.10)**

Reference Book:

1) D.M. Burton: *Elementary Number Theory*,1980 Universal Book Stall.

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MT-206: Classical Mechanics

1. Mechanics of particle, Mechanics of the system of particle, constraints, D'Alembert's principle and Lagrange's equations, velocity dependent potential and the dissipation function, simple applications of the Lagrangian formations. (**10 Hours)**

2. Hamilton's principle some techniques of the calculus of variations, Derivation of Lagrangian equations from Hamilton's principle, Extension of Hamilton's principle to nonholonomic system, conservation theorems and symmetry properties. **(10 Hours)**

3. The independent co-ordinates of a rigid body, orthogonal transformations Formal properties of the transformations matrix, The Euler angles, The Cayley-Klein parameters and related quantities finite rotations, Rate of the change of a vector, linear momentum, Angular momentum and Kinetic energy of motion about a point. Tensors and dyadics, The inertia tensor and the moment of inertia, The eigen values of the inertia tensor and Principle axis transformations. **(15 Hours)**

4. Legendre transformations and the Hamilton equation of motion, Derivation of Hamilton's equation from a variations principle, The principle of least action. **(10 Hours)**

5. The equations of canonical transformations, Generating Functions, Examples of Canonical transformations, Conditions for a transformation to be Canonical, Bilinear invariant conditions, Poisson Brackets, properties, Invariance of Poisson Brackets' with respect to Canonical transformations. **(15 Hours)**

Recommended Book:

1) H. Goldstein: *Classical Mechanics*, 2011 Addison Wesley.

Reference Books:

1) Carban and steble: *Classical Mechanics*, John Wiley press Cambridge
2) Marian: *Classical Dynamics*, Academic Press
3) Sudarsan & Mukunda: *Classical Mechanics*
4) J.C. Upadhyaya: *Classical Mechanics*, Himalaya Publishing House.

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SEMESTER III:

MT-301: Topics in Functional Analysis

1. Normed linear spaces, Banach Spaces, Quotient spaces, Continuous linear Transformations. The Hahn-Banach theorem and its consequences, conjugate space and separability, Second conjugate space. The natural embedding of normed linear space and its second conjugate space, Weak *Topology on conjugate space. The open mapping theorem, Projection on Banach space, The closed graph theorem, the conjugate of an operations, The uniform boundedness theorem (Banach-Steinhauss theorem). **(25 Hours)**

2. Inner Product spaces, Hilbert space: Definition, examples and simple properties, Schwartz's inequality, Orthogonal complements, Projection theorem, Orthogonal sets, The Bessel's inequality, Fourier expansion and Parseval's equations, Gram-Schmidt orthogonalization process, Separable Hilbert space, The conjugate space, Riesz Theorem, Operations and their adjoints on a Hilbert space, self adjoint operators, Normal and unitary operators projections. **(25 Hours)**

3. Finite dimensional spectral theory, Determinants and spectrum of an operator, The spectral theorem, Fixed points, Definition and examples, Banach contraction mapping theorem, Brouwer's fixed point theorem, Schauder's fixed point theorem. **(10 Hours)**

Recommended Books:

1) Simmons G. F.: Introduction to Topology and Modern Analysis, McGraw Hill Book Company New York 1963.
   (Chapter 9, Art 46 to 51. Chapter 10, Art 52 to 59, Chapter 11, Art 61 to 62, Appendix ONE)
2) B. Chaudhary and Sudarshan Nanda: Functional Analysis with applications, Wiley- Eastern.

Reference Books:

1) Bachman G and Narici L: Functional Analysis, Academic Press.
2) Berberian S. K.: Functional Analysis and Operator theory, McMillan New York.
3) Limaye B. V.: Functional Analysis, second editions, New Age International (P), Ltd., Publishers (1996) chapter 6 Art 21 to 24, Appendix A.
4) Siddique A. H.: Functional Analysis with applications, Wiley- Eastern Limited.

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MT-302: Statistical Techniques

1. Revision of Basic concepts: Discrete and Continuous series, Arithmetic Mean, Geometric Mean, Harmonic Mean, Median and Mode. Range, Quartile deviation, Mean deviation, Standard deviation, Variance and coefficient of variation. **(6 Hours)**

2. Probability: Sample space, discrete probability, Mathematical theory of probability, independent events, Addition and Multiplication theorems of probability, conditional probability and Baye's theorem. **(8 Hours)**

3. Theoretical distributions: Random variable, probability distribution of a discrete and continuous random variable. Probability density function, mathematical expectation. Binomial, Poisson and Normal distributions and their properties. **(8 Hours)**

4. Correlation: Definition, meaning, scatter diagram method, Karl Pearson's method, Probable error, Standard error and Rank correlation and concurrent deviations. **(8 Hours)**

5. Regression: Definition, meaning, two lines of regression, regression coefficients, standard error and relation between correlation and regression. **(8 Hours)**

6. Sampling and Large sample tests: Introduction to sampling, Simple random sampling, stratified sampling and systematic sampling. Testing of hypothesis, level of significance, tests of significance for large samples. Tests for single proportion, difference of proportion, single mean, difference of means, difference of S.D. **(10 Hours)**

7. Exact sampling distributions: Chi-Square variate and Chi-Square distribution, conditions of validity of Chi-Square test, applications of Chi-square distribution, Chi –Square test for population variance, Chi-square test for Goodness of fit and Independence of Attributes. Definition of student's 't' distribution and derivation, Fisher's 't' distribution constants of t-distribution, graph of t-distribution, application, test for single mean, test for difference of means, paired t-test testing significance of observed sample. Definition of F statistic, F-distribution, applications, F-test for equality of population variances. **(12 Hours)**

Recommended Book:

1) S.C. Gupta and V.K. Kapoor: Mathematical Statistics, Sultan Chand & Co-New Delhi.

Reference Books:

1) E.J. Dudewicz and S.N. Mishra, Modern Mathematical Statistics, John Willey & Sons.
2) Erwin Kreyszig: Introductory Mathematical Statistics, Willey International Ltd.
3) J.K. Goyal and J.N. Sharma: Mathematical Statistics, Krushna Prakashan.

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MT-303: Topics in Field Theory

1. Algebraic extensions, Splitting field, Algebraic closure, Separable and Inseparable extensions. Normal extension, Perfect fields of finite fields. **(30 Hours)**

2. Galois extensions, Fundamental theorem of Galois theory, Roots of unity, Solvability by radicals, Geometric construction, Transcendental extensions, Transcendental base. **(30 Hours)**

Recommended Book:

1) N.S. Gopalakrishnan, University Algebra, New Age International (P), Ltd., Publishers (2003) **(Chapter-4: Art.-4.1 to 4.9.)**

Reference Books:

1) N. Jacobson, Basic Algebra I, Second Edition, Hindustan Publishing Corporation (2012).
2) M. Nagata, Field Theory, Marcel-Dekker Inc. (1977).

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MT 304: Fluid Dynamics

1. Introduction: Basic concepts of Fluid Mechanics like pressure, density, external forces. Important types of flows and types of fluids. Some important formulae of vector calculus. **(10 Hours)**

2. Kinematics: Two methods of study, velocity and acceleration of fluid particle, equation of continuity, boundary conditions, boundary surface, stream lines, path lines and streak lines. Irrotational flow, velocity potential, vorticity vector, angular velocity and rotational motion**.** **(10 Hours)**

3. Equations of motion: Euler's equation of motion for inviscid fluids, impulsive forces and equation of motion, energy equation. One – dimensional inviscid incompressible flow and Bernoulli's theorem. **(10 Hours)**

4. Motion in two dimensions: Stream function, sources, sinks and doublets, Complex Potential, C-R equations in polar form, method and images, image with respect to a line and circle, Circle theorem, theorem of Blasius, Streaming Motion past a cylinder and sphere. **(10 Hours)**

5. General theory: General theory of irrotational motion, flow and circulation, Stoke's theorem, Green's theorem, Kelvin's theorem, Permanence of Irrotational motion, kinetic energy of infinite mass of liquid. **(10 Hours)**

6. Laminar flow: Real fluids, laminar flow for real fluids, N-S equations in Cartesian coordinates, some exact solutions of N-S equations, Coutte flow, Plane Poiseuille flow, theory of lubrication, flow through circular pipe, The Hagen – Poiseuille flow and laminar flow between co-axial cylinders**.** **(10 Hours)**

Recommended Books:

1) R.K. Rathy: An introduction to fluid Dynamics, IBH, 1985.
2) Roy Singhania: Fluid Mechanics, Sultan Chand & Co.
3) Vector Streetor: Hand book of fluid mechanics.

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MT-305: Difference Equations

1. Introduction, Difference Calculus- The Difference Operator, Summation, Generating functions and approximate summation. Linear Difference Equations-First order equations. General results for linear equations. Equations with constant coefficients. Applications. Equations with variable coefficients. Nonlinear equations that can be linearized. The z-transform **(15 Hours)**

2. Stability Theory-Initial value problems for linear systems. Stability of linear systems. Stability of nonlinear systems, Chaotic behavior. Asymptotic methods-Introduction. Asymptotic analysis of sums. Linear equations. Nonlinear equations**.** **(15 Hours)**

3. The self-adjoint second order linear equation. Introduction. Sturmian Theory. Green's functions. Disconjugacy. The Riccati Equation. Oscillation. The Strum-Liouville problem-Introduction, finite Fourier Analysis. A non-homogeneous problem. Discrete Calculus of variations-Introduction. Necessary conditions. Sufficient Conditions and Disconjugacy. **(15 Hours)**

4. Boundary value Problems for Nonlinear Equations-Introduction. The Lipschitz cases. Existence of solutions. Boundary Value Problems for Differential Equations. Partial Differential Equations. Discretization of Partial Differential Equations. Solution of Partial Differential Equations. **(15 Hours)**

Recommended Book:

1) Walter G. Kelley and Allan C. Perterson-Difference Equations. An Introduction with Applications. Academic Press Inc. Harcourt Brace Joranovich Publishers, 1991.

References Book:

1) Calvin Ahlbrandt and Allan C. Peterson, Discrete Hamiltonian Systems, Difference Equations, Continued Fractions and Ricati Equations, Kluwer, Boston, 1996

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MT-306: Theory of Lattices

1. Introduction to Posets, Semi-lattice, Two definitions of lattices, Congruence relations, Congruence lattice, The homomorphism theorem, Product of lattices, complete lattices, ideal lattice, Distributive and Modular Inequalities and Identities, Complements, Pseudocomplements, Boolean lattices, Boolean lattices of pseudo complements in a meet semi lattice. Atoms, Irreducibility of elements**.** **(18 Hours)**

2. Characterization theorem for modular and distributive lattice, Dedekind's characterization of modular lattice, Birkhoff's characterization of distributive lattices. Representation of distributive lattices, Stone theorem, Nabchin theorem, Hashimoto's theorem, Distributive lattice with pseudocomplementation, Stone lattice, characterization of Stone lattice. Stone algebra, characterization of Stone algebra. **(20 Hours)**

3. Distributive, Standard and Neutral elements **(10 Hours)**

4. Semimodular lattices and Modular pairs **(12 Hours)**

Recommended Book:

1) George Gratzer: General Lattice Theory, Birkhauser Verlag Basel.

(Chapter 1: Sections 1, 2, 3, 4, 6, Chapter 2: Sections 1 to 6 Chapter 3: Section 2, Chapter 4: Section 2).

Reference Books:

2) Birkhoff G., Lattice Theory.
3) Crawley P. and Dilworth R.P.: Algebraic Lattice Theory.
Davey B.A. and Priestly: Introduction to Lattices and Order

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MT-307: Elements of Graph Theory

1. Graphs: Definitions and examples, graphs as models, subgraphs, Operations on graphs, Matrix representation of graphs, walks, Trails, Paths, and Cycles. Connectedness and connectedness algorithm. **(10 Hours)**

2. Trees and Connectivity: definition and simple properties of a tree, Bridges, Spanning Trees, Cayley's Theorem, Kruskal's Algorithm, Prim's Algorithm, Shortest path problems, The Breadth First Search (BFS)algorithm, The Backtracing algorithm, Dijkstra's Algorithm, Cut vertices, Connectivity. **(12 Hours)**

3. Eulerian and Hamiltonian Graphs: Eulerian trails, Eulerian and semi Eulerian graphs, Fleury's algorithm, Hierholzer's algorithm, The Chinese Postman Problem, Hamiltonian graphs, Dirac theorem, Closure of a graph, Bondy and Chavatal theorem, Travelling salesman problem (optimal algorithms and the closest intersection algorithm are not expected). **(8 Hours)**

4. Matching: matching and augmenting paths, Berge theorem, The Hall's marriage problem, the personnel assignment problem and matching algorithm for bipartite graphs, The Hungarian algorithm. **(12 Hours)**

5. Planar graphs and Coloring of graphs: Plane and Planar graphs, Euler's Formula, Vertex coloring,Critical graphs, Cliques and edge coloring of graphs **.** **(10 Hours)**

6.Max- Flow, Min- Cut Theorem and Ramsey numbers: definition of Ramsey number, Relations among Ramsey numbers. **(8 Hours)**

Recommended Book:

1) John Clark and Derek Allan Holton: A First Look At Graph Theory, Allied Publishers Ltd.

Reference Books:

1) Bondy and Murthy: Graph Theory With Applications.
2) Bhave N.S. and T.T.Raghunathan: Elements of Graph Theory.
3) Harary F.: Graph Theory.
4) Parthsarathi K.R.: Basic Graph Theory.

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Semester IV

MT-401: Advanced Mathematical Methods

1. Integral Equations: Introduction and classification of Linear Integral equations; Integro-differential equations. Fredholm's equations, Degenerate kernels, Hermitian and Symmetric kernels. Volterra's equations and resolvent kernel; Convolution type of kernels. **(15 Hours)**

2. Fourier Transforms: The Fourier Integral, complex form of Fourier Integrals and Fourier Integral theorem; Fourier transforms; properties, Fourier Cosine and Sine Transforms, finite Fourier transforms, convolution theorem, Parsvals Identity and relationship between Fourier transforms and Laplace transforms. **(15 Hours)**

3. Calculus of Variations: A basic lemma, statement and formulation of several problems, the Euler-Laggrange equation, first integrals of Euler-Lagrange equation, Geodesics, Brachistochrome problem, Minimum surface of revolution, several dependent variables, Parametric representation,Undetermined end points, Brachistochrome from a given curve to a fixed point and the simple Isoperimetric problem. **(15 Hours)**

4. Z-transforms: Introduction, definition, formulae, properties, definition of inverse Z-transform, properties, application of z-transform to difference equations. **(15 Hours)**

Recommended Books:

1) L1. G. Chambers: A short course on Integral Equations, International text book company ltd.
2) Murray, J. Spiegel: Laplace Transforms, Schaum's outline Series.
3) Goyal and Gupta: Laplace transforms and Fourier transforms, Pragati Prakashan, Meerut.
4) Robert Weinstock: Calculus of Variations with applications to Physics and Engineering, McGraw-Hill Book company, New York.
5) B. S. Grewal: Advanced Engineering Mathematics.

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MT-402: Operations Research

1. PERT AND CPM: Introduction, Phases of project management, Network diagrams, Fulkerson's rule, slack, forward pass, backward pass, critical path, project duration, various floats, tabular form, differences between PERT and CPM, Project cost and crashing the Network. **(14 Hours)**

2. Queuing Models: Introduction, application of Queuing models, characteristics, arrival and service distribution, Kendall's notation for Queuing models, Single channel queuing theory, M/M/I model and generalization, M/M/I:SIRO/model, M/M/1: FCFS/N/Finite queue length model, M/M/1:FCFS/n/N Limited source model, M/M/C:FCFS/ / Multichannel queuing theory model. **(8 Hours)**

3. Decision theory: Steps involved in Decision theory, decision making under uncertainty, Minimax, Maximin, Maximax, Hurwitz and Laplace criteria. Decision making under risk, Expected monetary value and Expected opportunity loss criteria and EVPI, Decision trees.

(10 Hours)

4. Replacement Models: Introduction, Replacement of Items that deteriorate with time with no changes in money value, with change in value of money, replacement of items that fail suddenly, individual replacement policy, group replacement policy and staffing problems. **(6 Hours)**

5. Inventory Models: Necessity and maintenance of Inventory, inventory costs, inventory control problems, inventory models with deterministic demand, with probabilistic demand, with price breaks, multi-item deterministic models, forecasting of demand, forecasting methods, seasonal demand, when to order, safety stock and how much to order. **(8 Hours)**

6. Simulation: Introduction, when to use simulation, advantages and limitations of simulation technique, Monte Carlo method, generation of random numbers, time flow mechanism, simulation languages. **(6 Hours)**

7. Non-linear Programming: Quadratic program, Wolfe's algorithm, Beale's algorithm. Frank Wolfe's method, reduced gradient method, Kelly's cutting plane method, method of approximate programming, gradient projection method, Generalized Lagrange's multiplier technique, separable programming, linear fractional programming. **(8 Hours)**

Recommended Books:

1) V. K. Kapur: Quantitative Techniques for Management, Sultan Chand & Co. New Delhi.
2) P.K. Gupta and D.S. Hira: Operations Research, Sultan Chand & Co., New Delhi.

Reference Books:

1) Taha, Operations Research: An introduction, Macmillan publishing Co.
2) Vohra N D, Quantitative techniques in management, Tata Mc-Graw Hill.

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MT-403: Commutative Algebra

1. Modules, Free modules, Projective modules, Tensor product and Flat modules **(15 Hours)**

2. Noetherian modules, Primary decomposition, Artinian modules **(15 Hours)**

3. Integral extensions: Integral elements, Integral extensions and Integrally closed domain.

(15 Hours)

4. Dedekind domain: Valuation rings, Discrete valuation rings and Dedekind domains

(15 Hours)

Recommended Books:

1) N.S. Gopalkrishnan: Commutative Algebra, Second Edition, Universities Press (India) Pvt. Ltd. (2016).

   (**Chapter- I: Art.-1.1 to 1.4, Chapter-III: Art.- 3.1 to 3.3, Chapter-IV: Art.-4.1 to 4.3, Chapter-V: Art- 5.1 to 5.3.)**

Reference Books:

1) M.F. Atiyah and Mac Donald: Introduction to Commutative Algebra, Sarat Book House (2007).
2) N. Jacobson: Basic Algebra Vol- I & II, Hindustan Publishing Corporation(India) (1980).
3) O. Zarski and P. Samuel: Commutative Algebra, Springer (1975).
4) L. Rowen: Ring theory Vol-I & II, Academic Press (1988).

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MT-404: Advanced Abstract Algebra

1. Basic concepts of maximal ideals, prime ideals and nil radical of an ideal, semiprime ideals, primary ideals, Prime avoidance theorem. **(15 Hours)**

2. Jacobson radical of a ring, Semisimple ring, Prime radical of a ring, Quasi-regular element, J-radical, J-semisimple ring, Regular ring. **(15 Hours)**

3. Direct sum of rings, Subdirectly reducible and irreducible rings. **(15 Hours)**

4. Noetherian ring, irreducible ideals, irredundant primary representation, Cohen's theorem, Krull intersection theorem. **(15 Hours)**

Recommended Book :

1. D. M. Burton: A first course in ring and ideals, Addison-Wisley Publishing Company Inc.(1970).Chapter-V: Art.-5.1 to 5.16, Chapter-VIII: Art.- 8.1 to 8.21, Chapter-IX: Art.-9.4 to 9.6, Chapter-X: Art- 10.1 to 10.6, Chapter-XII: Art.-12.1 to 12.11.

Reference Book:

1. N. Jacobson: Basic Algebra Vol- I & II, Hindustan Publishing Corporation(India) (1980).

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MT-405: Advanced Numerical Methods

1. System of Linear Equations: Methods of triangularization – Do little algorithm, Crout's method, inverse of a matrix by Crout's method, Gauss Jordan method for system of linear equations, Iterative methods of Jacobi' and Gauss–Seidal, Relaxation method, convergence. **(12 Hours)**

2. Numerical Differentiation and Integration: Numerical differentiation using Forward, Backward, Central differences, Error analysis, higher derivatives of continuous and tabulated functions, maximum and minimum values of a function, difference tables and Richardson's extrapolation. Newton–Cotes Integration formulas, Trapezoidal rule, Simpson's 1/3 rule, Error Analysis, Romberg integration, Numerical Double integration by trapezoidal and Simpson's Rules. **(12 Hours)**

3. Numerical Solution of ODE (IVP): Initial value problems, Numerical Solution of O.D.E using Picard, Taylor series, Modified Euler and Runge-Kutta fourth order methods; Predictor corrector methods. **(8 Hours)**

4. Numerical Solution of ODE (BVP): Linear BVP, shooting method, alternative method, non-linear BVP – Secant method and Newton – Raphson method; Finite difference method of linear second order problems, derivative boundary condition, solution of tri-diagonal system. Iteration methods for non-linear seconder problems, Newton – Raphson method. **(10 Hours)**

5. Numerical solution of P.D.E. (BVP): Introduction, deriving difference equations; numerical solution of elliptic equations, Leibnitz's iteration method for Laplace equation and Poisson's equation; Solution of Heat equation; Bendor-Schmidt method, Crank-Nicholson method; Hyperbolic equations, finite difference method and starting values. **(18 Hours)**

Recommended Books:

1) M.K. Jain, S.R.K. Iyengar and R.K. Jain: Numerical methods for Scientific and Engineering Computation, New Age international Publishers.
2) V.N. Vedamurthy and N.Ch.S.N. Iyengar: Numerical methods, Vikash Publishing House.
3) C. Gerald and O. Wheatley: Applied Numerical Analysis, Addison Publishing company.

Reference Books:

1) E. Balagurswamy: Numerical Methods, Tata McGraw-Hill.
2) S.S. Sastry: Introductory methods of Numerical Analysis, Prentice Hall of India.

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MT-406: Algebraic Topology

1. Geometric complexes, polyhedron, orientation of Geometric complexes. **(10 Hours)**

2. Chains, Cycles, Boundaries, Homology groups, Examples and structure of homology groups, The Euler-Poincare theorem, Euler's theorem, Pseudo manifolds, Fundamental group of S_n**.** **(15 Hours)**

3. Simplicial approximation, Induced homomorphism on the homology groups, The Brouwer's fixed point theorem**.** **(15 Hours)**

4. Homotopic paths and Fundamental groups, Covering homotopy property for S_1, Examples of Fundamental groups, Relation between first homology group and fundamental group. **(20 Hours)**

Recommended Book:

1) F.H. Croom: Basic Concepts of Algebraic Topology, Springer under graduate text (1978).

(Chapter-I: Art- 1.1 to 1.4, Chapter-II: Art-2.1 to 2.5, Chapter-III: Art-3.1 to 3.4, and Chapter-IV: Art-4.1 to 4.4.)

Reference Books:

1) Satya Deo: Algebraic Topology-A primer, Hindustan Book Agency, (2003).
2) B. K. Lahiri: A First Course in Algebraic Topology, Second Edition, Alpha Science Intl Ltd; (2005).
3) I .M. Singer & J.A. Thorpe: Lecture Notes on Elementary Topology and Differential Geometry, Springer Verlag New York (1976).
4) E. H. Spanier: Algebraic Topology, Third Edition, Springer Verlag New York Inc. (1994).

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MT-407: Linear Integral Equations

1. Definition and classification of linear integral equations, Fredholm integral equation with separable kernel, Singular integral equations, Integrodifferential equations, Homogeneous Fredholm equations and eigenfunctions. **(15 Hours)**

2. Solutions of Fredholm integral equations by: Successive approximations Method, Successive substitution Method, Adomian decomposition method, Modified decomposition method, Resolvent kernel of Fredholm equations and its properties, Solutions of Volterra integral equations: Successive approximations method, Neumann series, Successive substitution Method. **(15 Hours)**

3. Solution of Volterra integral equations by Adomian decomposition method, and the modified decomposition method, Resolvent kernel of Volterra equations and its properties, Convolution type kernels, Applications of Laplace and Fourier transforms to solutions of Volterra integral equations, Symmetric Kernels: Fundamental properties of eigenvalues and eigenfunctions for symmetric kernels, expansion in eigenfunctions and bilinear form. **(15 Hours)**

4. Hilbert Schmidt Theorem and its consequences, Solution of symmetric integral equations, Operator method in the theory of integral equations, Solution of Volterra and Fredholm integrodifferential equations by Adomian decomposition method, Green's function: Definition, Construction of Green's function and its use in solving boundary value problems. **(15 Hours)**

Recommended Book(s):

1. R. P. Kanwal, Linear Integral Equation- Theory and Technique, Academic Press, 1971.
2. Abdul-Majid Wazwaz, Linear and Nonlinear Integral Equations-Methods and Applications, Springer, 2011.

Reference Books:

1. L. G. Chambers, Integral Equations- A Short Course, International Text Book Company, 1976.
2. M. A, Krasnov, et.al. Problems and exercises in Integral equations, Mir Publishers, 1971.
3. J. A. Cochran, The Analysis of Linear Integral Equations, McGraw Hill Pub., 1972.
4.C. D. Green, Integral Equation Methods, Thomas Nelson and sons, 1969.

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Equivalent courses for M. Sc. Mathematics

With Effect from June 2014	With Effect from June 2017
MT 101 Advanced Calculus	MT 101 Advanced Real Analysis
MT 102 General Topology	MT 102 Topology
MT 103 Algebra	MT 103 Abstract Algebra
MT 104 Ordinary and Partial Differential Equations	MT 104 Ordinary and Partial Differential Equations
MT 105 Fuzzy Sets and Their Applications	MT 105 Theory of Fuzzy sets
MT 106 Programming in C++	MT 106 Programming in C++
MT 201 Measure Theory and Integrations	MT 201 General Measure Theory
MT 202 Complex Variables	MT 202 Complex Analysis
MT 203 Linear Algebra	MT 203 Linear Algebra
MT 204 Mathematical Methods	MT 204 Mathematical Methods
MT 205 Analytic Number Theory	MT 205 Number Theory
MT 206 Classical Mechanics	MT 206 Classical Mechanics
MT 301 Topics in Functional Analysis	MT 301 Topics in Functional Analysis
MT 302 Fluid Dynamics	MT 304 Fluid Dynamics
MT 303 Topics in Field Theory	MT 303 Topics in Field Theory
MT 304 Statistical Techniques	MT 302 Statistical Techniques
MT 305 Mathematical Modelling	MT 305 Difference Equations
MT 306 Lattice Theory	**MT 306 Theory of Lattices**
MT 401 Advanced Mathematical Methods	MT 401 Advanced Mathematical Methods
MT 402 Operations Research	MT 402 Operations Research
MT 403 Commutative Algebra	MT 403 Commutative Algebra
MT 404 Graph Theory	**MT 307 Elements of Graph Theory**
MT 405 Advanced Numerical Methods	MT 405 Advanced Numerical Methods
MT 406 Algebraic Topology	MT 406 Algebraic Topology