Central University of Punjab, Bathinda

Course Scheme & Syllabus

for

M.Sc. MATEHMATICS

Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015
## Scheme of Programme M.Sc. Mathematics
### Semester-I

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Interdisciplinary courses offered by MAT Faculty (For students of other Centres)

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**C_A**: Continuous Assessment: Based on Objective Type Tests  
**M_1**: Mid-Term Test-1: Based on Objective Type & Subjective Type Test  
**M_2**: Mid-Term Test-2: Based on Objective Type & Subjective Type Test  
**E_T**: End-Term Exam (Final): Based on Objective Type Tests  
**T_M**: Total Marks  
C: Core; I_E: Interdisciplinary elective; F: Foundation; L: Lectures; T: Tutorial; P: Practical; Cr: Credits.

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**Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015**
## Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015

### Semester-II

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Interdisciplinary course offered by Mathematics Faculty for PG Students of Other Centre(s)

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**Note**: For elective course MAT.512, elective course MAT.513 is compulsory.
\[ C_A : \text{Continuous Assessment: Based on Objective Type Tests} \]
\[ M_1 : \text{Mid-Term Test-1: Based on Objective Type & Subjective Type Test} \]
\[ M_2 : \text{Mid-Term Test-2: Based on Objective Type & Subjective Type Test} \]
\[ E_T : \text{End-Term Exam (Final): Based on Objective Type Tests} \]
\[ T_M : \text{Total Marks} \]

C: Core; E: Elective; \[ I_E : \text{Interdisciplinary elective} \]; F: Foundation; L: Lectures; T: Tutorial; P: Practical; Cr: Credits.

Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015
### Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015

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### Notes:
- $C_A$: Continuous Assessment: Based on Objective Type Tests
- $M_1$: Mid-Term Test-1: Based on Objective Type & Subjective Type Test
- $M_2$: Mid-Term Test-2: Based on Objective Type & Subjective Type Test
- $E_T$: End-Term Exam (Final): Based on Objective Type Tests
- $T_M$: Total Marks
- C: Core; E: Elective; F: Foundation; L: Lectures; T: Tutorial; P: Practical; Cr: Credits.
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Cₐ: Continuous Assessment: Based on Objective Type Tests  
M₁: Mid-Term Test-1: Based on Objective Type & Subjective Type Test  
M₂: Mid-Term Test-2: Based on Objective Type & Subjective Type Test  
Eₜ: End-Term Exam (Final): Based on Objective Type Tests  
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**Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015**
Course Title: Research Methodology-I
Paper Code: MAT.401
Total Lectures: 30

Course Objective: The course Research Methodology - General has been framed to introduce basic concepts of Research Methods. The course covers preparation of research plan, reading and understanding of scientific papers, scientific writing, research proposal writing, ethics, plagiarism, laboratory safety issues etc.

Unit-I  
**Introduction:** Meaning and importance of research, Different types and styles of research, Role of serendipity, Critical thinking, Creativity and innovation, Hypothesis formulation and development of research plan, Art of reading, understanding and writing scientific papers, Literature survey, Interpretation of results and discussion, Poster preparation and presentation.

Unit-II  
**Library:** Classification systems, e-Library, Reference management, Web-based literature search engines, Intellectual property rights (IPRs).

**Entrepreneurship and Business Development:** Importance of entrepreneurship and its relevance in career growth, Types of enterprises and ownership.

Unit-III  
**Good Laboratory Practices:** Recent updates on good laboratory practices.

**Laboratory Safety Issues:** Lab, Workshop, Electrical, Health and fire safety, Safe disposal of hazardous materials.

Unit-IV  
**Intellectual Property Rights:** Intellectual Property, intellectual property protection (IPP) and Intellectual property rights (IPR), WTO (Word Trade Organization), WIPO (Word Intellectual property organization. GATT (General Agreement on Traffic and Trade), TRIPs (Trade Related Intellectual Property Rights) , TRIMS (Trade Related Investment Measures) and GATS (General Agreement on Trades in Services), Nuts and Bolts of Patenting, Ethics and Values in IP.

Recommended Books:
5. Word Trade Organization: [www.wto.org](http://www.wto.org)
Objective:
This course provides the foundation required for more advanced studies in Algebra. The aim is also to develop necessary prerequisites for MAT.506 (Algebra-II).

Unit I (16 Lecture Hours)
**Group Theory:** Review of basic concepts of Groups, subgroups, normal subgroups, quotient groups, Homomorphisms, cyclic groups, permutation groups, Even and odd permutations, Conjugacy classes of permutations, Alternating groups, Cayley's Theorem, class equations, Direct products, Fundamental Theorem for finite abelian groups.

Unit II (12 Lecture Hours)
Sylow theorems and their applications, Finite Simple groups Survey of some finite groups, Groups of order $p^2$, $pq$ ($p$ and $q$ primes). Solvable groups. Normal and subnormal series, composition series.

Unit III (13 Lecture Hours)
**Ring Theory:** Review of Rings, Zero Divisors, Nilpotent Elements and idempotents, Matrices, Ring of endomorphism, Ideals, Maximal and prime ideals, Nilpotent and nil ideals, Zorn’s Lemma.

Unit IV (14 Lecture Hours)
Polynomial rings in many variables, Factorization of polynomials in one variable over a field. Unique factorization domains. Gauss Lemma, Eisenstein’s Irreducibility Criterion, Unique Factorization in $\mathbb{R}[x]$, where $\mathbb{R}$ is a Unique Factorization Domain. Euclidean and Principal ideal domains.

Recommended Books:
Course Title: Real Analysis
Course Code: MAT.502
Total Lectures: 56

Objective: The aim of this course is to make the students learn fundamental concepts of metric spaces, Riemann-Stieltjes integral as a generalization of Riemann Integral, Sequence and series of functions, the calculus of several variables and some basic theorems.

Unit-I (15 Lecture Hours)
Metric spaces: Definition and examples, Open and closed sets, Compact sets, Elementary properties of compact sets, k-cells, Compactness of k-cells, Compact subsets of Euclidean space $\mathbb{R}^k$, Perfect sets, Cantor set, Separated sets, Connected sets in a metric space, Connected subsets of real line. Convergent sequences (in Metric spaces), Subsequences, Cauchy sequences, Complete metric space, Cantor's intersection theorem, Category of a set and Baire’s category theorem. Examples of complete metric space, Banach contraction principle.

Unit-II (15 Lecture Hours)
Limits of functions (in Metric spaces), Continuous functions, Continuity and compactness, Continuity and connectedness, Discontinuities, Monotonic functions, Uniform continuity. Riemann Stieltje’s Integral: Definition and existence of Integral, Properties of integral, Integration and differentiation, Riemann sums and Riemann integral. Fundamental theorem of Calculus, Integration of vector valued functions, Rectifiable curves.

Unit-III (13 Lecture Hours)

Unit-IV (13 Lecture Hours)
Functions of several variables, Linear transformation, Derivative is an open subject, Chain rule, Partial derivatives, Jacobian, Interchange of the order of differentiation, Derivation of higher order, Inverse function theorem, Implicit function theorem.

Recommended Books:

Suggested Readings:

Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015
Course Title: Differential Equations

Paper Code: MAT.503

Total Lectures: 56

Objective:
The objective of this course is to equip the students with knowledge of some advanced concepts related to differential equations and to understand some basic approach to mathematical oriented differential equation.

Unit I  
Initial value problem, Existence of solutions of ordinary differential equations of first order, Existence and Uniqueness theorem, Regular and Singular points, Singular solutions for first order ODEs, System of first order ODEs, General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, method of undetermined coefficients, reduction of the order of equation, method of Laplace’s transform.

Unit II  
Lipchilz’s condition, Picards theorems, dependence of solution on initial conditions and on function, Continuation of solutions, Non local existence of solutions. Green’s function and its applications.

Unit III  
Simultaneous differential equations, orthogonal trajectories, Boundary value problems, Sturm Liouville’s boundary value problems. Sturm comparison and Separation theorems, Orthogonality solution.

Unit IV  
Classification of first order PDE, Classification of second order PDE, Lagrange’s linear PDE, Charpit’s method. Well posed and Ill-posed problems, Monge’s method, General solution of higher order PDEs with constant Coefficients, Separation of variables method for parabolic, hyperbolic, elliptic, Laplace, heat and wave equations.

Recommended books:

Course Title: Linear Algebra

Paper Code: MAT.504

Total Lectures: 56

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Objective:
The concepts and techniques from linear algebra are of fundamental importance in many scientific disciplines. The main objective is to introduce basic notions in linear algebra that are often used in mathematics and other sciences. The emphasis will be to combine the abstract concepts with examples in order to intensify the understanding of the subject.

Unit I  
**Vector Space:** vector spaces, subspaces, direct sum of subspaces, linear dependence and independence, basis and dimensions, linear transformations, quotient spaces, algebra of linear transformations, linear functionals, Change of Basis, dual spaces, matrix representation of a linear transformation, rank and nullity of a linear transformation, invariant subspaces.

Unit II  
(15 Lecture Hours)
Characteristic polynomial and minimal polynomial of a linear transformation, eigenvalues and eigenvectors of a linear transformation, diagonalization and triangularization of a matrix, Cayley Hamilton Theorem, Canonical forms, Diagonal forms, triangular forms, Jordan Canonical Forms.

Unit III  
(14 Lecture Hours)

Unit IV  
(13 Lecture Hours)
The Adjoint of a Linear operator on an inner product space, Normal and self-Adjoint Operators, Unitary and Normal Operators, Reduction and classification of quadratic forms.

Recommended books:
4. V.Bist and V. Sahai, *Linear Algebra* (Narosa, Delhi).

Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015
Objective:
The objective of the course is to provide foundation for other related branches of Mathematics. Most of the topics covered are widely applicable in Applied Mathematics and Engineering.

Unit I (13 Lecture Hours)
Review of Complex number system, Algebra of complex numbers, the complex plane, Function of a complex variable, Limit, Continuity, Uniform continuity, Differentiability, Analytic function, Cauchy- Riemann equations, Harmonic functions and Harmonic conjugate, Construction of analytic functions.

Unit II (14 Lecture Hours)
Complex line integral, Cauchy’s theorem, Cauchy-Goursat theorem, Cauchy’s integral formula and its generalized form. Index of a point with respect to a closed curve, Cauchy’s inequality. Poisson’s integral formula, Morera’s theorem. Liouville’s theorem, Contour integral, Power series, Taylor’s series, Higher order derivatives, Laurent’s series.

Unit III (14 Lecture Hours)
Singularities of analytic functions, Casorati-Weierstrass theorem, Fundamental theorem of algebra, Zeroes of analytic function, Poles, Residues, Residue theorem and its applications to contour integrals, Branches of many valued functions with arg z, log z, and z^a. Maximum modulus principle, Schwarz lemma, Open mapping theorem.

Unit IV (13 Lecture Hours)
Meromorphic functions, The argument principle, Rouche’s theorem, Mobius transformations and their properties and classification, Definition and examples of conformal mappings.

Recommended books:
Objective: To provide the understanding and use of mathematical techniques for students of other departments.

Unit I (10 Lecture Hours)
Ordered pairs, Cartesian product of sets. Number of elements in the Cartesian product of two finite sets. Cartesian product of the reals with itself (upto $\mathbb{R} \times \mathbb{R} \times \mathbb{R}$). Definition of relation, pictorial diagrams, domain, co-domain and range of a relation. Function as a special kind of relation from one set to another. Pictorial representation of a function, domain, co-domain and range of a function. Real valued function of the real variable, domain and range of these functions, constant, identity, polynomial, rational, functions.

Unit II (10 Lecture Hours)

Unit III (8 Lecture Hours)
Need for complex numbers, especially $\sqrt{-1}$, to be motivated by inability to solve every quadratic equation. Brief description of algebraic properties of complex numbers. Argand plane and polar representation of complex numbers. Statement of Fundamental Theorem of Algebra,

Unit IV (8 Lecture Hours)
Matrix and determinants, properties of determinants, eigen values and eigen vectors, Derivatives, differential equations, order and degree of differential equations, solution of first order differential equations. Definite integral and its properties

Recommended books:
Course Title: Computational Methods
Paper Code: MAT.403
Total Lectures: 30

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Objective: The course on Computational Methods has been framed to equip the students of M.Sc. Physics with knowledge of programming in C, roots of equation, interpolation, curve fitting, numerical differentiation, numerical integration, solution of ordinary differential equations and probability.

Unit-I (07 Lecture Hours)
Programming with C: Introduction to the concept of object oriented programming, Advantages of C over conventional programming languages, Introduction to classes, objects, C programming syntax for Input/Output, Operators, Loops, Decisions, Simple and inline functions, Arrays, Strings, Pointers.

Unit-II (07 Lecture Hours)
Roots of Algebraic and Transcendental Equations: Element of computational techniques: roots of functions, Interpolation, Extrapolation, One point and two-point iterative methods such as bisection method and Newton Raphson methods.

Unit-III (08 Lecture Hours)
Integration and Differential: Integration by Trapezoidal and Simpson’s rule, Solution of first order differential equation using Runge-Kutta methods, Finite difference methods.
Data Interpretation and Error analysis: Dimensional analysis, Precision and accuracy, error analysis, Propagation and errors.

Unit-IV (08 Lecture Hours)
Least square fitting: Least square fitting, Linear and nonlinear curve fitting, Chi square test.
Random numbers: Introduction to random numbers, Monte Carlo method for random number generation.
Probability Theory: Elementary probability theory, Random variables, Binomial, poisson and normal distributions, Central limit theorem.

Recommended Books:

Course Title: Computational Methods Laboratory
Paper Code: MAT.404
Total Hours: 60

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Objective: The laboratory exercises have been so designed that the students learn to verify some of the mathematical concepts. They are trained in carrying out numerical problems using C language.

Student has to perform at least eight experiments out of the following list of experiments.

1. Data handling: find standard deviation, mean, variance, moments etc. of at least 25 entries.
2. Choose a set of 10 values and find the least squared fitted curve.
3. To find the roots of quadratic equations.
4. Perform numerical integration on 1-D function using Simpson rules.
5. Perform numerical integration on 1-D function using Trapezoid rule.
6. To generate random numbers between (i) 1 and 0, (ii) 1 and 100.
7. To find the value of π using Monte Carlo simulation.
8. To find the solution of differential equation using Runge-Kutta method.
9. To find the solution of differential equation using Euler’s method.
10. To find the value of y for given value of x using Newton’s interpolation method.

Recommended Books:
Course Title: Algebra – II
Paper Code: MAT.506
Total Hours: 56

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Objective:
This course is a basic course in Algebra for students who wish to pursue research work in Algebra. Contents have been designed in accordance with the UGC syllabi in mind.

Unit I (13 Lecture Hours)
Field Theory: Basic concepts of Field theory, Extension of fields, algebraic and transcendental extensions. Splitting fields, Separable and inseparable extensions, Algebraically closed fields, Perfect fields.

Unit II (14 Lecture Hours)
Galois Theory: Galois extensions, the fundamental theorem of Galois theory, Cyclotomic extensions, and Cyclic extensions, Applications of cyclotomic extensions and Galois theory to the constructability of regular polygons, Solvability of polynomials by radicals.

Unit III (15 Lecture Hours)
Modules: Difference between Modules and Vector Spaces, Module Homomorphisms, Quotient Module, Completely reducible or Semi simple Modules, Free Modules, Representation and Rank of Linear Mappings, Smith normal Form over a PID, Finitely generated modules over a PID, Rational Canonical Form, Applications to finitely generated abelian groups.

Unit IV (14 Lecture Hours)

Recommended Books:

4. V.Bist and V. Sahai, Linear Algebra (Narosa, Delhi), 2002.
Objective: The course is an introductory course on point-set topology. It is designed in such a way that the students will have a working knowledge in general topology and be able to understand more advanced topics like Algebraic Topology, Differential Topology, Riemannian Geometry and allied areas.

Unit-I (12 Lecture Hours)

Unit-II (16 Lecture Hours)

Unit-III (14 Lecture Hours)
Connected spaces, Connected subspaces of the real line, Components and path components, Local connectedness. Compact spaces, Sequentially compact spaces, Heine-Borel Theorem, Compact subspaces of the real line, Limit point compactness, Local –compactness and one point compactification.

Unit-IV (14 Lecture Hours)

Recommended Books:

Suggested Readings:
Objectives:
The objective of this paper is to introduce the concept of kinematics of a rigid body rotating about fixed point, Newton’s laws, Projectile motion under gravity and Moments and products of Inertia etc.

Unit I  (8 Lecture Hours)
Velocity and acceleration of a particle along a curve, Radial & Transverse components (plane motion). Relative velocity and acceleration. Kinematics of a rigid body rotating about a fixed point. Vector angular velocity.

Unit II  (8 Lecture Hours)

Unit III  (8 Lecture Hours)
Projectile motion under gravity, constrained particle motion, angular momentum of a particle. The cycloid and its dynamical properties.

Unit IV  (8 Lecture Hours)
Moments and products of Inertia, Theorems of parallel and perpendicular axes, angular motion of a rigid body about a fixed point and about fixed axes.

Recommended books:
Course Title: Probability and Statistics
Paper Code: MAT.509
Total Hours: 56

Objectives:
The course is designed to equip the students with various probability distributions and to develop greater skills and understanding of Sampling and Estimation.

Unit I
(13 Lecture Hours)
Probability: Definition of probability-classical, relative frequency, statistical and axiomatic approach, Addition theorem, Boole’s inequality, Conditional probability and multiplication theorem, Independent events, Mutual and pairwise independence of events, Bayes’ theorem and its applications.

Unit II
(14 Lecture Hours)

Unit III
(14 Lecture Hours)
Discrete distributions: Uniform, Bernoulli, binomial, Poisson and geometric distributions with their properties.
Continuous distributions: Uniform, Exponential, Gamma and Normal distributions with their properties. Central Limit Theorem (Statement only).
Statistical estimation: Parameter and statistic, sampling distribution and standard error of estimate. Point and interval estimation, Unbiasedness, Efficiency.

Unit IV
(15 Lecture Hours)
Sampling Theory: Types of Sampling, errors in sampling, Parameter and Statistic, Tests of Significance: Null Hypothesis, Alternative Hypothesis, One-tailed, Two-tailed tests. Sampling Attributes: Tests of Significance for single proportion and difference of proportions. Sampling of Variables.

Recommended books:
Course Title: Distribution Theory

Paper Code: MAT.510

Total Hours: 56

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Objectives:
The course is designed to equip the students with distribution theory and to develop greater skills and understanding of Sampling and Estimation.

Unit I

Descriptive Statistics: Meaning, need and importance of statistics. Attributes and variables. Measurement and measurement scales. Collection and tabulation of data. Diagrammatic representation of frequency distribution: histogram, frequency polygon, frequency curve, ogives, stem and leaf plot, pie chart. Measures of central tendency, dispersion (including box and whisker plot), skewness and kurtosis. Data on two attributes, independence and association of attributes in 2x2 tables. Linear regression and correlation (Karl Pearson’s and Spearman’s) and residual plots.

Unit II


Unit III


Unit IV


Recommended Books:

Course Title: Special Functions
Paper Code: MAT.511
Total Hours: 56

Objective:
The objective of this course is to introduce the special function as a solution of specific differential equations.

Unit I

Hypergeometric Functions: The hypergeometric series, An integral formula for the hypergeometric series, The hypergeometric equation, Linear relations between the solutions of the hypergeometric equation, Relations of contiguity, The confluent hypergeometric function, Generalised hypergeometric series.

Unit II

Legendre Functions: Legendre polynomials, Recurrence relations for the Legendre polynomials, The formulae of Murphy and Roderigues, Series of Legendre polynomials, Legendre’s differential equation, Neumann’s formula for the Legendre functions, Recurrence relations for the functions Qn (µ), The use of Legendre functions in potential theory, Legendre’s associated functions, Integral expression for the associated Legendre function, Surface spherical harmonics, Use of associated Legendre functions in wave mechanics.

Unit III

Bessel Functions: The origin of Bessel functions, Recurrence relations for the Bessel coefficients, Series expansions for the Bessel coefficients, Integral expressions for the Bessel coefficients, The addition formula for the Bessel coefficients, Bessel’s differential equation, Spherical Bessel functions, Integrals involving Bessel functions, The modified Bessel functions, The Ber and Bei functions, Expansions in series of Bessel functions, The use of Bessel functions in potential theory, Asymptotic expansion of Bessel functions.

Unit IV


Recommended books:
5. W. W. Bell, Special Functions for Scientists and Engineers, Dover, 1968.
Course Title: Fundaments of Computer science and programming in C and C++

Paper Code: MAT.512
Total Hours: 46

Course Objective: The objective of this course is to develop understanding of different software and hardware systems available in industry among the participants and to build up the experience of computer usage in business organizations with specific reference to commercial data processing systems.

Unit I
Basic Concepts: Historical development of C, Primary memory, Secondary storage devices, Input and Output devices, Significance of software in computer system, Categories of software – System software, Application software, Compiler, Interpreter, Utility program, Binary arithmetic for integer and fractional numbers, Operating System and its significance.

Unit II

Unit III

Unit IV
Functions in C++: Passing arguments to and returning values from functions. Classes and objects: Specifying and using class and object, Arrays within a class, Arrays of objects, Object as a function arguments. Operator Overloading and Type Conversions: Overloading unary, binary operators. Inheritance: General concepts of Inheritance, Types of derivation-public, private, protected. Files and Streams: Streams, Stream classes for console operations, Unformatted I/O operations, Formatted console I/O operations.

Recommended books:
Course Title: Fundaments of Computer science and programming in C and C++  LAB

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<th>Paper Code: MAT.513</th>
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<td>Total Hours: 46</td>
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Laboratory experiments will be set in context with the materials covered in theory.
Course Title: Advanced Complex Analysis
Paper Code: MAT.514
Total Hours: 56

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Objectives:
This course is designed to enable the readers to understand further deeper topics of Complex Analysis and will provide basic topics needed for students to pursue research in pure Mathematics.

Unit –I (15 Lecture Hours)
Harmonic function: Definition, Relation between a harmonic function and an analytic function, Examples, Harmonic Conjugate of a harmonic function, Poisson's Integral formula, Mean Value Property, The maximum & minimum principles for harmonic functions, Dirichlet Problem for a disc and uniqueness of its solution, Characterization of harmonic functions by Mean Value Property.

Unit –II (14 Lecture Hours)

Unit –III (14 Lecture Hours)
Weierstrass Elliptic functions: Periodic functions, Simply periodic functions, fundamental period, Jacobi's first and second question, Doubly periodic functions, Elliptic functions, Pair of Primitive Periods, Congruent points, First and Second Liouville's Theorem, Relation between zeros and poles of an elliptic function, Definition of Weierstrass elliptic function (z) and their properties, The differential equation satisfied by (z) [i.e., the relation between (z) and (z)], Integral formula for (z), Addition theorem and Duplication formula for (z).

Unit IV (13 Lecture Hours)
Weierstrass Zeta function: Weierstrass Zeta function and their properties, Quasi periodicity of (z), Weierstrass sigma function (z) and their properties, Quasiperiodicity of (z), associated sigma functions.

Reference Books:
Course Title: Advanced Partial Differential Equations  
Paper Code: MAT.515  
Total Hours: 56

Objectives:
The objective of this course is to equip the students with knowledge of some basic as well as advanced concepts related to partial differential equations and to understand some basic approach to mathematical oriented PDEs.

Unit I (15 Lecture Hours)
Distribution-Test Functions and Distributions, Examples, Operations on Distributions, Supports and Singular Supports, Convolution, Fundamental Solutions, Fourier Transform, Schwartz space, Tempered Distributions.
Sobolev spaces-Basic properties, Approximation by smooth functions, Extension theorems, Compactness theorems, Dual spaces, Functional order spaces, Trace spaces, Trace theory, Inclusion theorem.

Unit II (14 Lecture Hours)

Unit III (13 Lecture Hours)
Evolution Equations- Unbounded linear operators, $C_0$ – Semigroups, Hille-Yosida theorem, Contraction Semigroup on Hilbert Spaces, Heat equation, Wave equation, Schrodinger equation, Inhomogeneous equations.

Unit IV (14 Lecture Hours)

Reference Books:

Course Title: Linear Programming

Paper Code: MAT.405

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<th>Unit</th>
<th>(Lecture Hours)</th>
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<td>Unit I</td>
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<tr>
<td>Formulation of linear programming problems (LPP). Graphical solution to LPPs. Cases of unique and multiple optimal solutions. Unbounded solutions and infeasibility, and redundant constraints.</td>
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<td>Unit II</td>
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<td>Unit III</td>
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<td>Transportation problems, formulation of transportation problem, Feasible and optimal solution of transportation problems. Assignment problems.</td>
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<td>Unit IV</td>
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<td>Theory of Games: Introduction to basic concepts of game theory including strategic Games.</td>
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Recommended books:
Course Title: Numerical Methods
Paper Code: MAT.406

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<tr>
<th>Unit I</th>
<th>(6 Lecture Hours)</th>
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<td>Error Analysis</td>
<td>Relative error, Truncation error, Roundoff error, order of approximation, order of convergence, Propagation.</td>
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<tr>
<th>Unit II</th>
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<tr>
<th>Unit III</th>
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<td>Interpolation and Polynomial Approximation, Lagrange’s Method, Newton’s polynomials.</td>
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<th>Unit IV</th>
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Recommended books:
Semester-III

Course Title: Research Methodology-II
Course Code: MAT.407
Total Hours: 32

Objectives:
The objective of this course is to equip the students with knowledge of some basic as well as advanced concepts related to research. The course covers preparation of research plan, reading and understanding of scientific papers, scientific writing, research proposal writing, ethics, plagiarism etc.

Unit-I
Formulation of Research Problem and Hypothesis:
Hypothesis: The meaning, Importance, Type of sources, Characteristics of a usable hypothesis, The use of hypothesis in different types of research, Different forms of hypothesis in different types of research, Different forms of hypothesis, Difficulties in formulation of hypothesis, Testing the hypothesis

Unit-II
Literature Survey: References, Abstraction of a research paper, Possible ways of getting oneself abreast of current literature

Unit-III
Documentation and Scientific Writing: Result and conclusions; Preparation of manuscript for publication of research paper, Presenting a paper in scientific seminar, thesis writing. Structure and components of research report, Types of reports, Thesis, Research project reports, Pictures and graphs, Citation styles, Writing a review of paper, Bibliography.

Unit-IV
Computer Applications: Use of word processing, Spreadsheet and database software. Plotting of graphs. Internet and its applications: Email, WWW., Web browsing, acquiring technical skills, drawing inferences from data

Recommended Books:
Course Title: Measure Theory

Paper Code: MAT.601

Total Hours: 55

Objective: The objective of this course is to introduce student’s measure theory in an abstract setting after having studied Lebesgue measure on real line. Some important theorems are also studied.

Unit-I (14 Lecture Hours)
Semi-algebras, Algebras, Monotone class, $\sigma$ -algebras, Measure and outer measures, Caratheödory extension process of extending a measure on a semi-algebra to generated $\sigma$ -algebra, Completion of a measure space.

Unit-II (14 Lecture Hours)

Unit-III (14 Lecture Hours)
Measurable functions on a measure space and their properties, Borel and Lebesgue measurable functions, Simple functions and their integrals, Littlewood’s three principle (statement only), Lebesgue integral on $\mathbb{R}$ and its properties.

Unit-IV (14 Lecture Hours)
Bounded convergence theorem, Fatou’s lemma, Lebesgue monotone convergence theorem, Lebesgue dominated convergence theorem, Minkowski’s and Hölder’s inequalities, Riesz-Fischer theorem (statement only).

Recommended Books:

Suggested Readings:

Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015
Course Title: Differential Geometry of Curves and Surfaces

Paper Code: MAT.602
Total Hours: 56

Objective: To introduce students to the local and global theory of curves and surfaces so that they can be enabled for further studies and research in Differentiable Manifolds, Differential Topology, Algebraic Topology, Riemannian Geometry.

Unit-I (14 Lecture Hours)

Unit-II (14 Lecture Hours)

Unit-III (14 Lecture Hours)
Second fundamental form, Curvature of curves on a surface, Normal and Principal curvatures, Meusnier’s theorem, Euler’s theorem, Geometric interpretation of principal curvatures, Umbilical points. Gaussian and Mean curvature, Flat surfaces, Surfaces of constant mean curvature, Gaussian curvature of compact surfaces, Gauss map.

Unit-IV (14 Lecture Hours)
Geodesics: Definition and basic properties, Geodesic equations, Geodesics on a surfaces of revolution, Clairaut’s theorem, Geodesics as shortest paths, Geodesic coordinates, Gauss Theorem, Egregium, Gauss equations, Codazzi-Mainardi equations, Compact surfaces of constant Gaussian curvature.

Recommended Books:

Suggested Readings:
Course Title: Operational Research

Paper Code: MAT.603

Total Hours: 56

Objective:
The objective of this course is to acquaint the students with the concept of convex sets, their properties, linear and nonlinear programming problems. The results, methods and techniques contained in this paper are very well suited to the realistic problems in almost every area.

Unit-I (14 Lecture Hours)

Unit-II (14 Lecture Hours)

Unit-III (14 Lecture Hours)

Unit -IV (14 Lecture Hours)
Replacement problem, replacement of items that Deteriorate, replacement of items that fails completely. Job Sequencing Problems; Introduction and assumption, Processing of n jobs through two machines, Processing of n jobs through three machines and m machines, Processing two jobs through n machines.

Recommended books:

Suggested Readings:

Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015
Course Title: Numerical Analysis
Course Code: MAT.604
Total Hours: 45

Objective:
The aim of this course is to teach the applications of various numerical techniques for a variety of problems occurring in daily life. At the end of the course, the students will be able to do programming in C/C++/MATLAB and understand the basic concepts in Numerical Analysis of differential equations.

Unit-I
(11 Lecture Hours)


Unit-II
(11 Lecture Hours)
Eigen Value Problems: Power method and Jacobi method.
Polynomial Interpolation: Interpolating polynomial, Lagrange and Newton divided difference interpolation, Error in interpolation, Finite difference formulas, Hermite Interpolation.

Unit-III
(12 Lecture Hours)

Spline and Approximation: Cubic Spline, B-Spline, Least square method, Pâde approximation, Chebyshev Approximation.
Numerical Differentiation: Numerical differentiation with finite differences, Errors in numerical differentiation.
Numerical Integration: Trapezoidal rule, Simpson's 1/3 - rule, Simpson's 3/8 rule, Error estimates for Trapezoidal rule and Simpson's rule, Gauss quadrature formulas.

Unit-IV
(11 Lecture Hours)


Recommended Books:
Course Title: Numerical Analysis (Lab)  
Course Code: MAT.605  
Total Hours: 30

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Objective: Laboratory experiments will be set in context with the materials covered in theory in C/C++/MATLAB.

Laboratory work: Programming exercises on numerical methods using C/C++/MATLAB languages.
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<th>Course Title: Seminar</th>
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Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015
Course Title: Discrete Mathematics
Course Code: MAT.606
Total Hours: 56

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Objectives:
The objective of this course is to acquaint the students with the concepts in Discrete Mathematics. It includes the topics like logics, graph theory, trees and Boolean algebra.

Unit-I

Unit-II
Set Theory: Paradox in set theory, Inductive definition of sets and proof by induction; Peano postulates; Relations: Representation of relations by graphs, Properties of relations, Equivalence relations and partitions, Partial orderings, Linear and well-ordered sets;

Unit-III

Unit-IV

Recommended books:
**Course Title:** Number Theory

**Course Code:** MAT.607

**Total Hours:** 56

**Objective:**
The objective of this course is to teach the fundamentals of different branches of Number Theory, namely, Geometry of Numbers and Analytic Number Theory.

**Unit-I** (14 Lecture Hours)
Divisibility of Integers, Greatest common divisor, Euclidean algorithm. The fundamental theorem of arithmetic, Congruences, Residue classes and reduced residue classes.

**Unit-II** (14 Lecture Hours)
Indices and its applications, Quadratic residues, Euler’s criterion, Product of quadratic residues and quadratic non-residues, The Legendre symbol and its properties, Gauss’s lemma, Quadratic reciprocity law, Jacobi symbol and its properties.

**Unit-III** (14 Lecture Hours)
Chinese remainder theorem, Fermat’s little theorem, Wilson’s theorem, Euler’s theorem. Arithmetic functions $\sigma(n)$, $d(n)$, $\tau(n)$, $\mu(n)$, Order of an integer modulo $n$, primitive roots for primes, composite numbers having primitive roots.

**Unit-IV** (14 Lecture Hours)
Representation of an integer as a sum of two and four squares. Diophantine equations $ax + by = c$, $x^2 + y^2 = z^2$ and its application to $x^4 + y^4 = z^4$. Farey sequences, Continued fractions.

**Recommended books:**

**Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015**
Course Title: Fuzzy Sets and Fuzzy Logic  
Course Code: MAT.608  
Total Hours: 56

Objective:
The objective of this course is to acquaint the students with the concept of fuzzy logics.

Unit-I  
**Fuzzy Sets**-Basic definitions, α-level sets, Convex fuzzy sets, Basic operations on fuzzy sets, Types of fuzzy sets, Cartesian products, Algebraic products, Bounded sum and difference, T-norms and t-conorms, The Extensions principle- The Zadeh’s extension principle, Image and inverse image of fuzzy sets, Fuzzy Numbers, Elements of fuzzy arithmetic.  

Unit-II  

Unit-III  

Unit-IV  
**Fuzzy logic**- An overview of classical logic, Multivalued logics. Fuzzy propositions. Fuzzy Quantifiers. Linguistic variables and hedges. Inference from conditional fuzzy propositions, the compositional rule of inference.

Recommended books:

Course Title: Functional Analysis
Course Code: MAT.609
Total Hours: 56

Objective: The objective of this course is to introduce basic concepts, methods of Functional Analysis and its Applications. It is a first level course in Functional Analysis.

Unit-I (13 Lecture Hours)
Fundamentals of Normed Linear Spaces: Normed Linear spaces, Banach spaces and examples, finite dimensional normed spaces and subspaces, compactness and finite dimension. Quotient space of normed linear spaces and its completeness.

Unit-II (14 Lecture Hours)
Weak convergence and bounded linear transformations, Normed linear spaces of bounded linear transformations, Dual spaces with examples.
Three Main Theorems on Banach Space: Uniform boundedness theorem and some of its consequences, Open mapping and closed graph theorems.

Unit-III (14 Lecture Hours)

Unit-IV (15 Lecture Hours)

Recommended books:
Course Title: Calculus of variation and integral equations
Course Code: MAT.610
Total Hours: 56

Objective:
The objectives of the course calculus of variations and integral equations is to develop knowledge of the basic tenets of the theory of integral equations and mastery of the respective solutions of problems and exercises, knowledge of the main provisions of the calculus of variations and the ability to use the concepts and methods of the theory in solving problems arising in theoretical and mathematical physics.

Unit-I
(14 Lecture Hours)

Unit-II
(14 Lecture Hours)
Isoperimetric problems, Geodesics, Geodesics on a sphere of radius ‘a’, variational problem with several variables, functionals dependent on one or two functions, derivation of basic formula, variational problems with moving boundaries, Broken extremals: Weierstrass –Erdmann conditions.

Unit-III
(14 Lecture Hours)

Unit-IV
(14 Lecture Hours)
Fredholm Equations: Solution by the method of successive approximations. Solution of Fredholm integral equation for degenerate kernel, Solution by the successive approximations, Numann series and resolvent kernel.

Recommended books:
**Course Title:** Mathematical Methods  

**Course Code:** 611  

**Total Hours:** 56  

**Objective:**  
The objective of the course is to provide foundation for other related branches of Mathematics. Most of the topics covered are widely applicable in Applied Mathematics and Engineering.

**UNIT-I**  

**Laplace Transform:** Laplace transform and inversion formulas, First shifting theorem, Laplace transform of the derivatives and of the Integrals of a function, Derivatives and Integrals of Laplace transforms, Convolution products, Applications of Laplace transform in initial and boundary value problems, heat, wave and Laplace equations.

**UNIT-II**  

**Fourier Transform:** Fourier integrals, Fourier cosine and sine integrals, Inverse Fourier transform, Fourier cosine and sine transform, Complex form of the Fourier transform, Linearity of the Fourier transform. Discrete Fourier transforms (DFT), Relationship of FT and fast Fourier transforms (FFT), Applications of FT to heat conduction, vibrations and potential problems.

**UNIT-III**  

**Fourier series:** Periodic functions, Trigonometric series, Fourier series, Euler formulas, Functions having arbitrary periods, Even and Odd functions, Half-range expansions, Determination of Fourier coefficients without integration, Approximation by trigonometric polynomials, Square error.

**UNIT-IV:**  

**Applications of ODEs:** Applications of differential equations to vibrations of mass in a spring, Free undamped motion, Free damped motion, Forced motion, Resonance phenomenon and Electric circuit problems.

**Series Solutions:** Power series solutions, Bessel and Legendre differential equations, Generating functions and recurrence relations.

**Recommended Books:**  
Course Title: Dissertation Research
Course Code: MAT.600
Total Hours: 112

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Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015
Course Title: Advanced Numerical Analysis

Course Code: 612

Total Hours: 56

Objectives: The objective of the course is to familiarize the students about some advanced numerical techniques e.g. solving systems of nonlinear equations, linear system of equations, Eigen value problems, Interpolation and Approximation techniques and their use in differentiation and integration, differential equations etc.

UNIT- I (15 Lecture Hours)
Non-Linear Equations: Methods for multiple roots, Muller’s, Iteration and Newton-Raphson method for non-linear system of equations, and Newton-Raphson method for complex roots.
Polynomial Equations: Descartes’ rule of signs, Birge-Vieta, Bairstow and Giraffe’s methods.
System of Linear Equations: Triangularization, Cholesky and Partition methods, SOR method with optimal relaxation parameters.

UNIT-II (13 Lecture Hours)
Eigen-Values of Real Symmetric Matrix: Similarity transformations, Gerschgorin’s bound(s) on eigenvalues, Givens, Householder and Rutishauser methods.
Interpolation and Approximation: B - Spline and bivariate interpolation, Gram-Schmidt orthogonalisation process and approximation by orthogonal polynomial, Legendre and Chebyshev polynomials and approximation.

UNIT- III (13 Lecture Hours)
Differentiation and Integration: Differentiation and integration using cubic splines, Romberg integration and multiple integrals.
Ordinary Differential Equations: Shooting and finite difference methods for second order boundary value problems, Applications of cubic spline to ordinary differential equation of boundary value type.

UNIT- IV (15 Lecture Hours)

Recommended Books:

Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015
Course Title: Differential Topology  
Course Code: MAT.613  
Total Hours: 56

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Objective: To introduce students to the basics of Differential Topology so that they are able to appreciate better the topics covered in allied courses like Differential Geometry of Curves and Surfaces and Riemannian Geometry, as well as be adequately prepared for pursuing research in these topics.

UNIT-I  
(14 Lecture Hours)
The standard differential structure on the Euclidean space $\mathbb{R}^n$. Definition of manifold as a submanifold of $\mathbb{R}^n$, The standard abstract definition of manifolds using transition functions; Examples including the spheres, Real projective spaces, Higher genus surfaces. Definition of orientability of a manifold with examples (To discuss why Moebius band, Real projective plane and Klein bottle are not orientable).

UNIT-II  
(14 Lecture Hours)
Smooth maps and diffeomorphisms, the inverse function theorem, immersion and submersion, embedding, local immersion and local submersion theorems, critical and regular points (values) of a smooth map. Support of a function, bump functions, smooth version of Urysohn's Lemma for a manifold, Partition of unity.

UNIT-III  
(13 Lecture Hours)

UNIT-IV  
(15 Lecture Hours)
Definition and examples of Lie groups and Lie algebras, homomorphism, Left and right translations of a Lie group, Left (right) invariant vector fields, Lie algebra of a Lie group, Interpretation of the space of left (right) invariant vector fields of a Lie group G as the tangent space to G at the identity. Exponential map, One-parameter subgroups; Closed subgroups, Cartan's theorem and Adjoint representation of a Lie group.

Recommended Books:

Suggested Readings:

Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015
**Course Title:** Algebraic Topology  
**Course Code:** MAT.614  
**Total Hours:** 56

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**Objective:** The objective of this course is to introduce the student’s concept in Algebraic topology so that they can pursue research in this field and its allied areas.

**Unit-I**  
(14 Lecture Hours)  

**Unit-II**  
(13 Lecture Hours)  

**Unit-III**  
(15 Lecture Hours)  

**Unit-IV**  
(15 Lecture Hours)  

**Recommended Books:**

**Suggested Readings:**

Syllabi Applicable for Admissions in M. Sc. (Mathematics), 2015