Syllabus of M.Sc. Mathematics Programme w.e.f. 2018-2019

List of Courses:

(I) CORE COURSES

MTC-101: Real Analysis
MTC-102: Linear Algebra
MTC -103: Basic Algebra
MTC -104: Differential Equations
MTC -105: Topology
MTC -201: Several Variable Calculus
MTC -202: Algebra
MTC -203: Functional Analysis

(II) OPTIONAL COURSES

MTO -106: Methods of Applied Mathematics
MTO -107: Graphs and Networks
MTO -108: Actuarial Science
MTO -204: Partial Differential Equations
MTO -205: Complex Analysis
MTO -206: Measure Theory
MTO -207: Number Theory
MTO -208: Lie Algebra
MTO -209: Special Functions
MTO -210: Difference Equations
MTO -301: Advanced Algebra
MTO -302: Combinatorics
MTO -303: Differential Geometry
MTO -304: Mathematical Modeling
MTO -305: Integral Equations
MTO -306: Sturm Liouville Problem
MTO -307: Mathematics for Finance
MTO -401: Advanced Linear Algebra
MTO -402: Commutative Algebra
MTD-500: Dissertation

Note: All the courses are of 4 credit

Scheme of Instructions (Semester system)
Choice Based Credit System

SEMESTER (I)		
Course Number and Name	No. Of Credits	L- T- P (hours per week)
MTC-101- Real Analysis	4	3-1-0
MTC-102 -Linear Algebra	4	3-1-0
MTC-103- Basic algebra	4	3-1-0
Optional Course	4	3-1-0
SEMESTER (II)		
MTC-104- Differential Equations	4	3-1-0
MTC-105 – Topology	4	3-1-0
MTC-201 – Several Variable Calculus	4	3-1-0
Optional Course	4	3-1-0
SEMESTER (III)		
MTC-202 –Algebra	4	3-1-0
MATH-203-Functional Analysis	4	3-1-0
Optional Course	4	3-1-0
Optional Course	4	3-1-0
SEMESTER (IV)		
Optional Course	4	3-1-0
Optional Course	4	3-1-0
Optional Course	4	3-1-0
Optional Course	4	3-1-0

Detail Syllabus

Programme: M. Sc. (Mathematics)
Course Code: MTC-101 **Title of the Course:** REAL ANALYSIS
Number of Credits: 4
Effective from AY: 2018-19

Prerequisites	Basic Mathematical Analysis	
Objective	This course will develop fundamental concepts in Real Analysis and make the student acquainted with tools of analysis which is essential for the study and appreciation of many related branches of mathematics and applications.	
Content	**1.Real and Complex Number Systems** Peano's Axioms for Natural Numbers and Induction Principle, Integers and Rational numbers, Ordered sets and LUB Property, Ordered Field Axioms, Real Numbers and Completeness, Archimedean property, integral part of a real number, density of rationals, and irrationals, Existence of n^{th} roots of nonnegative reals and decimal representation of reals, Complex Number System, Countable sets , Uncountable sets, Countabilty of Rationals, Uncountability of Reals, Extended Real Number System.	12 Hours
	2.Elements of Point Set Toplogy Metric Spaces, Euclidean Spaces, Open balls and Open sets in $\mathbb{R}^n$, Structure of open sets in $\mathbb{R}^1$, Adherent points and Accumulation points, Closed sets, Perfect sets, Bolzano- Weierstrass Theorem, Cantor Intersection Theorem, Lindelöf Covering Theorem, The Heine-Borel Covering Theorem, Compactness in $\mathbb{R}^n$, Compactness in metric spaces, Connected sets in metric spaces, Connected subsets of $\mathbb{R}$, Cantor set.	12 Hours
	3.Limits and Continuity Convergent sequences in a Metric space , Cauchy sequences and Complete metric spaces, Limit inferior and Limit superior of a sequence, Limit of a Function- (Real valued, complex valued, vector valued functions), Continuous Functions, Continuity and Compactness, Continuity and Connectedness, Bolzano's Theorem and Intermediate value Theorem, Uniform Continuity, Uniform Continuity and Compactness, Discontinuities of Real valued Functions, Monotonic Functions, Infinite limits and Limits at infinity.	12 Hours
	4.Derivatives Derivatives and Continuity, Algebra of Derivatives and Chain rule (Statements only),One sided derivatives and Infinite Derivatives, Functions with non-zero derivatives, Zero derivatives and Local extrema, Rolle's Theorem, Mean value Theorems and consequences, Intermediate value Theorem for Derivatives, Taylor's Formula with Remainder, Derivatives of Vector valued Functions and Complex valued Functions, Derivatives of Higher Order and L'Hospital's Rules.	12 Hours
Pedagogy	Lectures/ Tutorials/Assignments/Self-study	
References/ Readings	1. Mathematical Analysis, Tom M. Apostol, Narosa Publishing House, 1996. 2. Principles of Mathematical Analysis, Walter Rudin, McGraw-Hill International Editions,1976. 3. A Basic Course in Real Analysis, Kumar and Kumaresan, CRC Press, 2015. 4. Real Analysis, N.L. Carothers, Cambridge University Press, 2000.	
Learning Outcomes	On Completion of this course the student will be able to • Describe the difference between rational numbers and real numbers. • Understand LUB property and apply it to proofs and solutions of problems. • Calculate limit inferior and limit superior • Understand and use concepts related to metric spaces such as continuity, compactness and connectedness • Apply mean value theorem to problems in the context of Real Analysis	

Programme: M.Sc. Mathematics

Course Code: MTC-102 **Title of the Course: LINEAR ALGEBRA**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Should have passed B.Sc. with Linear Algebra as one of the subjects. Should be familiar with the notions of vector spaces, basis, dimension, Linear maps, matrix representation of linear maps and their algebra and Rank-Nullity theorem.	
Objectives	To prepare students to handle solving problems involving linear equations and determining the qualitative properties of the solution set.	
Contents	1. **Basic Linear Algebra**: Vectors Spaces, Examples, Linear combinations, Linear Span, Linear dependence and independence, basis and dimension. (Review)	4 Hours
	2. **Linear Maps**: Linear maps, Matrix Representation, Algebra of Linear maps and Matrices, Rank Nullity theorem. (Review)	4 Hours
	3. **Linear functionals** : Linear functional on a vector space, Dual of a vector space and properties, Transpose of a linear map and the matrix.	8 Hours
	4. **Diagonalisation**: Characteristic values and characteristic vectors, Invariant subspaces, diagonalization. (Review).	4 Hours
	5. **Inner Product spaces**: Inner product spaces , examples and basic properties, Parallelogram law, Orthonormalisation of a basis, Bessel's inequality, Linear fucntionals on inner-product spaces, dual, Riesz Representation theorem.	10Hours
	6. **Linear operators**: Linear operators on inner-product spaces, adjoint of an operator, Unitary, self-adjoint and normal operators, Spectral theorem for self-adjoint and normal operators.	16Hours
Pedagogy	Class room lectures and tutorials, assignments and library reference.	
References	1. Kenneth Hoffmann and Ray Kunze, Linear Algebra, PHI, 1997. 2. S. Kumaresan, Linear Algebra, PHI, 2000.	
Learning Outcomes	The students will be equipped to learn basic Functional analysis, Several Variable Calculus, Advanced Algebra, Differential Equations, etc.	

Programme: M. Sc. (Mathematics)

Course Code: MTC-103 **Title of the Course:** Basic Algebra

Number of Credits: 4

Effective from AY: 2018-19

Prerequisites for the course:	Basic group Theory. Basic set theory. Notion of function and relation.	
Objective:	This course is also prerequisite for courses such as Algebra, Commutative Algebra, Advanced Number Theory, Galois Theory.	
Content:	**1. Logic:** Mathematical statements, Quantifiers, Conjuction and Disjunction, Negation, Implications and Converses, Equivalence of Statements.	3 hours
	2. Set Theory: Familiarising Zarmilo-Frankel Axioms, Expressing Sets, Set Operations, Ordered Pairs of Points, Product of sets.	5 hours
	3. Relations: Equivalence Relations, Equivalence Classes and Quotient as a Set, Cross-sections.	5 hours
	4. Functions: Function from Sets to Sets, Images, Pre-images and their Algebra, One-one and Onto Functions and Quotient Map, Schauder-Bernstein Theorem, Cardinality.	5 hours
	5. Natural Number system: Partial Order, Well-ordered set, Well-ordering Principle, Axiom of Choice, Order Preserving Functions, Order Isomorphism, Peano's Axiom.	5 hours
	6. Groups and subgroups: Definition and examples of groups, Cyclic groups, Permutations groups, Dihedral groups, Some matrix groups.	9 hours
	7. Cosets and Direct Products: Group of Permutations, Orbits, cycles and Alternating groups. Subgroups, Cosets and Theorem of Lagrange's, Euler's Theorem, Wilson's Theorem, Direct products and Finitely generated abelian groups, class equations and p-groups.	9 hours
	8. Homomorphism and Factor groups: Homomorphisms and Factor groups and Fundamental theorem of Group Homomorphisms. Isomorphism Theorems.	7 hours
Pedagogy:	lectures/ tutorials/assignments/self-study	
References/Readings	1. J.B. Fraleigh, A First Course in Abstract Algebra, Seventh Edition, Pearson International, 2002. 2. I. N. Herstein, Topics in Algebra, Second Edition, Wiely Student Edition, 2006. 3. V. Kakkar, Set Theory, Narosa Publisher, 2016. 4. A. Kumar, S. Kumaresan and B.K. Sarma, A Foundation Course in Mathematics, Narosa Publisher, 2018.	
Learning Outcomes	1. Taking this course students get prepared to take more advanced courses such as Algebra, Advanced Algebra. 2. Taking this course students can then read Galois theory and Rings and Field Theory.	

Programme: M.Sc. Mathematics

Course Code: MTC -104 **Title of the Course: DIFFERENTIAL EQUATIONS**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Knowledge of basic Real Analysis and Linear Algebra.	
Objectives	This course develops the ability to solve ordinary differential equations by standard methods. It will help to understand some important properties of solution of differential equation	
Contents	1. Review of Basic concepts: Linear differential equations of the first order. Higher order Linear differential equations with constant coefficients.	12 hours
	2. Linear Equations with variable coefficients. Standard methods and series solution. Legendre equation. Bessel's equation.	12 hours
	3. Systems of Linear differential equations. Existence and uniqueness of solutions of first order equation and nth-order equation.	12 hours
	4. Self adjoint second order differential equation. Sturm Liouville Problems. Greens functions. Zeros of solutions. Comparison Theorems. Linear oscillations. Oscillations of $x''(t) + a(t)x(t) = 0$.	12 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References	**<u>Main Texts:</u>** 1 . Deo S.G.; Raghvendra V.; Lakshmikantham V. : Text book of Ordinary Differential equations, 2nd edition, Tata McGraw Hill, New Delhi 1997. 2 . E.A. Coddington; An introduction to Ordinary Differential Equations, Prentice Hall,India,2003. **<u>Reference texts :</u>** 3. Kelly W. Patterson A.C. : Theory of Differential equations, Springer. 4. Simmons G. F. Differential equations with historical notes. Tata MH. 5. Agarwal R. Essentials of Ordinary differential equations, Springer.	
Learning Outcomes	Students will learn to solve ordinary differential equations and to analyse the properties of solution.	

Programme: M.Sc. Mathematics

Course Code: MTC -105 **Title of the Course: TOPOLOGY**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Should have undergone a basic course in Real Analysis. Should be familiar with the notions of set theory. It is desirable to have familiarity with the metric topology.
Objectives	To prepare students to handle courses involving topology and geometry including complex analysis, functional analysis and several variable calculus.
Contents	**1. Topological Spaces and Continuous Functions**: Definition of Topological spaces, basis, subbasis, open sets, closed sets, limit points, closure, interior, subspaces, continuous functions, Product Topology and quotient topology. — 12 hours **2. Countability Properties**: First and second countable spaces, Separable spaces, Metric spaces and countability properties. — 6 hours **3. Separation Properties**: Hausdorff spaces, Regular spaces and normal spaces, Product, subspace and continuous images of regular and normal spaces. — 6 hours **4. Connectedness**: Connected spaces, connected subsets of ℝ, path connected spaces, Product and continuous images of connected spaces, locally connected spaces, components and path components. — 10 hours **5. Compactness**: Compact subsets of topological spaces, Compact subsets of ℝ, Products and continuous images of compact subsets, Compact Hausdorff spaces, Limit point compactness, Sequential compactness, Comapct metric spaces, Lebesgue number lemma, Locally compact spaces and one-point compactification. — 14 hours
Pedagogy	Class room lectures and tutorials, assignments and library reference.
References	1.James Munkres, Topology and Introduction, Pearson Education, 2002. 2. Stephen Willard, General Topology, 3. M A Amstrong, Basic Topology, Springer Verlag, 1983. 4. J. Dugunji, Topology
Learning Outcomes	Students will be prepared to undertake basic courses in Complex Analysis, Functional Analysis, Several Variable Calculus, Measure Theory etc. and advanced courses in Topology and Geometry.

Programme: M.Sc. Mathematics

Course Code: MTO-106 **Title of the Course: METHODS OF APPLIED MATHEMATICS**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Knowledge of basic Real Analysis, Linear Algebra, Differential Equations.
Objectives	This course develops the ability to apply mathematics to some of the problems of Mathematics and Physics.
Contents	**1. Improper Integrals**. Review , Properties and L^2 convergence. — 6 hours **2. Fourier series**: Generalized Fourier series, Fourier sine/cosine series. Point wise and uniform convergence. Differentiation and integration of Fourier series. — 12 hours **3. Fourier Transforms and its properties**: : Fourier Transform of L^1 (IR)—functions. Basic properties related to translation, dilation and linearity. Computation of Fourier transform of simple functions. Fourier Inversion. Statement of Fourier inversion Theorem. Convolution. Convolution Theorem. Examples. Parsevaal's Identity. — 10 hours **4. Variational problems**: Variational problems with fixed boundaries. Euler-Lagrange equations, Brachistochrone problem, Elementary variational problems with moving boundaries. One-side variation, Isoperimetric problem, Canonical forms of Euler equations. Sufficient conditions for extremum. — 20 hours
Pedagogy	Lectures/ tutorials/assignments/self-study
References	**<u>Main Texts:</u>** 1. J.W.Brown and R.V.Churchill, Fourier series and Boundary Value Problems, McGraw Hill. 2. K.Sankara Rao, Introduction to Partial Differential Equations, Prentice Hall of India, 1995. 3. Lev Elsgolts, Introduction to the Calculus of Variations, MIR Publications. 4. T.Apostal Mathematical analysis, Narosa Publishers. **<u>Reference texts :</u>** 4. G.B.Arfken and H. Weber, Mathematical methods for Physicists. Elsevier Publications. 5. R. Weinstock, Calculus of Variations, Dover Publication. 6. I.M.Gelfand and S.V.Fomin, Calculus of Variations. Dover Publication.
Learning Outcomes	1. Theory and applications of Fourier Series 2. Learns techniques of applying Fourier Transform. 3. Understands basic concepts of variational problems

Programme: M.Sc. (Mathematics)

Course Code: MTO-107 **Title of the Course:** GRAPHS AND NETWORKS

Number of Credits: 4

Effective from AY: 2018-2019

Prerequisites	**Basic set theory**	
Objective	Course deals with the basics of graph theory, basic definition of simple graphs, types of graph, matrix representation of graphs, isomorphism in graphs, Euler & Hamiltonian graphs, trees & their properties, spanning trees, colouring of graphs, independence number and chromatic number of simple graphs, connectivity, cut-set, directed graphs, shortest paths & maximal flows in a network.	
Content	**1. Introduction to graphs** Graphs, degree sequence, distance in graphs, digraphs and multidigraphs, Cut-vertices bridges and blocks.	11 hours
	2. Trees and connectivity Elementary properties of trees, minimal spanning trees, Prims algorithm, Kruskal's algorithm, connectivity and edge-connectivity, connectedness of digraphs.	7 hours
	3. Eulerian and Hamiltonian graphs Eulerian graphs and digraphs, Hamiltonian graphs and digraphs, Fleury's algorithm and Hierholzer's algorithm.	7 hours
	4. Planar graphs Euler's formula, characterizations of planar graphs, crossing number and thickness.	7 hours
	5. Graph colorings Vertex colorings, edge colorings, map colourings.	5 hours
	6. Matchings and domination in graphs Matchings and independence in graphs, domination number of a graph, independence domination number of a graph.	4 hours
	7. Networks Relevance of maximum flow, Ford Fulkerson algorithm, Dijkstra's algorithm to find the shortest route.	7 hours
Pedagogy	Lectures/ Tutorials/Assignments/Self-study	
References/Readings:	1. G. Agnarsson and R. Greenlaw, Graph Theory: Modeling, Applications and algorithms, Pearson , 2011. 2. Gary Chartrand and Ping Zhang, Introduction to Graph Theory, Tata Mc-Graw-Hill Edition, 2006. 3. F. Harary, Graph Theory, Narosa Publishing House, 2001. 4. Gary Chartrand and O.R. Oellermann, Applied Algorithmic Graph Theory, McGraw-Hill Inc. 1993. 5. L.R. Foulds, Graph Theory Applications, Springer Verlag, New York, 2009.	
Learning Outcomes:	Learner should be able to tell relevance of graphs in different context, ranging from puzzles & games to social science/engineering/computer science. Problem solving & learning algorithms is also an essential part of graph theory.	

Programme: M.Sc. Mathematics

Course Code: MTO-108 **Title of the Course: Actuarial Science**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Basic Real Analysis	
Objectives	This course will prepare a student to understand the basics of insurance and related concepts.	
Contents	1. Basic concepts of actuarial science and insurance. Accumulated Value, Present Value. Principals of compound interest: Normal and effective rates of interest and discount, force of interest and discount. Compound interest, accumulation factor. Annuities certain. Deferred annuities, annuities due. Redemption of Loans. Sinking Funds and Capital redemption assurance.	16 hours
	2. Life insurance: Insurance payable at the moment's of death and at the end of the year of death-level benefit insurance, endowment insurance, differed insurance and varying benefit insurances, recursions, commutation functions. Life annuities : Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportion able annuities -due.	18 hours
	3. The Mortality tables. Functions and laws of mortality tables. Select ultimate and aggregate mortality tables. Functions other than yearly policy Values. Surrender values and paid up Values. Bonus Special policies. Joint life and last survivor statuses.	14 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References	1. N./L Bower, H.U.Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt (1986), Actuarial Mathematics society of Actuaries, Itasca, Illinois, USA Second Edition (1997) 2. Spurgeon E.T. (1972), Life Contingencies, Cambridge University Press. 3. Neill, A. (1977). Life Contingencies, Heinemann. 4. M.A. Mackenzie, N.E. Sheppard, An Introduction to the Theory Of Life Contingencies, 1931. 5. P. Zima & R.L. Brown, Mathematics of Finance, Schaum's Outline series. 6. Elements of actuarial science Premiums, Mortality and valuation Federation of insurance institutes P.M. road, Mumbai.	
Learning Outcomes	Students will be able to understand various insurance schemes and will be prepared to take up career in Insurance industry.	

Programme: M.Sc. Mathematics

Course Code: MTC-201 Title of the Course: SEVERAL VARIABLE CALCULUS

Number of Credits: 04

Effective from: June, 2018.

<table>
<tr><td>Prerequisites</td><td colspan="2">Knowledge of basic Real Analysis and Linear Algebra. Knowledge of Integration of real valued functions on a subset of R is desirable</td></tr>
<tr><td>Objectives</td><td colspan="2">This course develops the ability to understand concepts of functions of severable variables.</td></tr>
<tr><td rowspan="3">Contents</td><td>1. Derivative of Function of more than one Variable: Partial Derivative. Total derivative of function of more than one Variable. Jacobian. Sufficient Condition for differentiability. Mean Value Theorem. Higher order derivatives. Condition for Equality of Mixed Partial Derivatives. Taylor's Theorem. Critical Points. Maximum, Minimum. Second Derivative condition for Maximum/minimum. Conditional Optimum and Lagrange Multipliers.</td><td>16 hours</td></tr>
<tr><td>2. Inverse Function Theorem: Regular and Singular Points. Open Mapping Theorem. Inverse Function Theorem. Implicit Function Theorem.</td><td>8 hours</td></tr>
<tr><td>3.Riemann Integration: Rectangles in IR^n and Riemann sums over Rectangles. Upper and Lower Riemann Sums. Riemann Integral of a bounded Function. Algebra of Riemann Integrals. Sets of Jordan Measure Zero. Oscillation of a Function at a point, Integrability versus points of discontinuity of a Function. Fubini's Theorem. Mean value theorem for multiple integrals. Partitions of unity (Statement only). Change of variable formula.</td><td>24 hours</td></tr>
<tr><td>Pedagogy</td><td colspan="2">Lectures/ tutorials/assignments/self-study</td></tr>
<tr><td>References</td><td colspan="2"><u>Main Texts:</u>
1. Tom M Apostol, Mathematical Analysis, Addison Wesley Publishing Company, 1996.
2. M. Spivak, Calculus on Manifolds, Benjamin Cummings, London.
<u>Reference texts :</u>
3. Walter Rudin, Principles of Mathematical Analysis, International Student Edition.
4. James Munkres, Analysis on Manifolds, Addison Wesley Publishing Company,1991.
5. T. M. Apostol , Calculus Vol.II. John Wiley and sons.
6. B.V.Limaye & S.Ghorpade, A course in multivariable calculus,Springer</td></tr>
<tr><td>Learning Outcomes</td><td colspan="2">Learn to understand the concepts of functions of several variables. Compute maximum/minimum of functions of several variables and to evaluate multiple integrals.</td></tr>
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Programme: M. Sc. (Mathematics)

Course Code: MTC-202 **Title of the Course:** ALGEBRA

Number of Credits: 4

Effective from AY: 2018-19

Prerequisites	Basic Group Theory	
Objective	This course develops concepts in advanced Group Theory, Basics of Ring Theory and their applications., This course will also be a prerequisite for courses such as Field Theory and Galois Theory and Commutative Algebra.	
Content	**1. Sylow Theorems** Conjugacy Classes. The Class Equation. The probability that two elements commute. The Sylow Theorems. Applications of Sylow Theorems. **2. Finite Simple Groups** Non simplicity Tests. The simplicity of A_5 **3. Rings and Fields** Rings. Fields. Integral Domains-definitions and Examples. Characteristic of Rings. Ideals and Factor Rings. Prime ideals and Maximal ideals. Ring Homomorphisms. Field of Quotients of an Integral Domain. **4. Polynomial Rings and Factorization of Polynomials** Polynomial Rings-Notations and Terminologies, The Division algorithm and Consequences, Reducibility Tests, Irreducibility Tests, Unique factorization in $\mathbb{Z}[x]$. **5. Divisibility in Integral Domains** Irreducibles. Primes. Unique Factorization Domains. Principal Ideal Domains. Euclidean Domains. Gaussian Integers and Fermat's $p = a^2+b^2$ Theorem.	12 Hours 4 Hours 12 Hours 8 Hours 12 Hours
Pedagogy	Lectures/ Tutorials/Assignments/Self-study	
References/ Readings	1. Contemporary Abstract Algebra, Joseph A. Gallian, Narosa Publishing House,1999. 2. A First Course in Absract Algebra, John B. Fraleigh, Pearson (India), 2014. 3. Topics in Algebra, I.N.Herstein, Wiley India Edition,2006. 4. Abstract Algebra, David S.Dummit and Richard M. Foote, Second Edition, John Wiley & Sons, 1999.	
Learning Outcomes	On completion of this course ,the student will be able to • Explain Concepts in Algebra regarding Groups, Rings and related structures, and develop the ability to work with various algebraic structures. • Lay foundation for research topics in Algebra, Number Theory, Algebraic Geometry etc.	

Programme: M. Sc. (Mathematics)

Course Code: MTC-203 **Title of the Course:** FUNCTION ALANALYSIS

Number of Credits: 4

Effective from AY: 2018-19

Prerequisites	A first course in Real Analysis, Linear Algebra and Metric Toplogy. Basic understanding of Lebesgue Integral Theory is desirable.	
Objective	Starting with the basics this course will cover the foundations of Functional Analysis such as normed spaces, inner product spaces, Banach spaces, Hilbert spaces, bounded linear operators and bounded functional, and the four fundamental theorems-Han-Banach Theorem. Uniform Boundedness Principle, Open Mapping Theorem and Closed Graph Theorem.	
Content	**1.Normed Spaces, Banach Spaces** Normed spaces- Properties and Banach spaces, Standard normed spaces – Sequence spaces , Function spaces and subspaces, Finite dimensional normed spaces and subspaces, Equivalence of norms, Compactness and finite dimension, Linear Operators-Boundedness and Continuity. Linear functional. Normed spaces of Operators, Dual space-Algebraic and Topological duals. **2.Inner Product Spaces, Hilbert Spaces** Inner Product Spaces- Properties and Hilbert spaces, Orthogonal Complement and Direct Sums, Orthonormal Sets and Sequences, Total Orthonormal Sets and Sequences, Representation of Functional on Hilbert Spaces, Hilbert -Adjoint Operator, Self Adjoint, Unitary and Normal Operators. **3.Fundamental Theorems for Normed and Banach Spaces** Hahn-Banach Theorem **(**Statements and idea of proof for the case of vector spaces, statement and proof for normed spaces**)**,Applications to Existence of Functionals, Adjoint Operators, Reflexivity of Spaces, Baire Category Theorem **(**Statement only**)**, Uniform Boundedness Theorem, Open Mapping Theorem, Closed Graph Theorem.	16 Hours 16 Hours 16 Hours
Pedagogy	Lectures/ Tutorials/Assignments/Self-study	
References/ Readings	1. Introductory Functional Analysis with Applications, Ervin Kreyszig, John Wiley & Sons, 1978. 2.Functional Analysis, Balmohan V. Limaye, III edition. 3. Functional Analysis: A First Course, M. Thamban Nair, PHI Learning, 2001. 4. Basic Operator Theory, Israyel Gohberg and Seymour Goldberg, Birkhäuser, 1981. 5. Linear Real analysis for Scientists and Engineers, B.V.Limaye, Springer.	
Learning Outcomes	On completion of the course the student will have • Understanding of the basic concepts and fundamental theorems of Functional Analysis • Appreciation of Functional Analysis as an important field for application oriented Mathematics. • Ability to relate and apply the concepts learnt in the course to problems. • Foundation for higher courses in Functional analysis, Operator Theory, PDE etc.	

Programme: M.Sc. Mathematics
Course Code: MTO-204 **Title of the Course: PARTIAL DIFFERENTIAL EQUATIONS**
Number of Credits: 04
Effective from: June, 2018.

Prerequisites	Knowledge of Real Analysis, Calculus of Several Variables, Ordinary differential equations, Methods of Applied Mathematics.	
Objectives	This course develops the ability to solve partial differential equations of first and second order by standard methods.	
Contents	**1.Simultaneous differential equations of the first and first degree in three variables:** Methods of solutions of $dx/P = dy/Q = dz/R$. Pfaffian differential forms and equations. Solution of Pfaffian differential equations in three variables.	4 hours
	2. First order PDE's: Origin and classifications. Solution of Linear and Nonlinear First order PDE's. Methods of characteristics. Charpit's Methods. Jacobi's method.	12 hours
	3. Second Order Linear Partial Differential Equations: Origin. Linear equations with constant coefficients in two independence Variables. Linear equations with variable coefficients. Classification. Reduction to Canonical Form. (only for the case of two independent variables).	6 hours
	4. Methods of solving PDE : Method of Separation of variables. Use of Integral transforms (Laplace and Fourier).	8 hours
	5. Wave Equation. One dimensional Wave equation.D' Alembert' solution, Wave equation-Infinite string case. **Laplace Equation :** Harmonic function . Basic properties of harmonic functions. Laplace equation. Translational and rotational invariance of Laplace equation. Boundary value problems. Uniqueness of solutions of Dirichlet and Neumann problems. Mean value theorem for harmonic functions. Maximum and minimum principle for harmonic functions. Uniqueness and stability for Dirichlet problem. **Heat equation-** Infinite rod case. Non homogeneous equation.	18 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References	**Main Texts:** 1. I. Sneddon, Elements of Partial Differential Equations, McGrow Hill. 2. T.Amarnath, An elementary course in Partial Differential Equations, Narosa Publishing company, 1997**.** **Reference texts :** 3.K.Sankara Rao, Introduction to Partial Differential Equations, Prentice Hall of India, 1995. 4. F.John, Partial Differential equations, Springer Verlag Ltd. 5. C.R. Chester, Techniques of Partial Differential Equations. 6. R.Dennemeyer, *Introduction to Partial Differential Equations and Boundary Value Problems*, McGraw Hill. 7. T.M. Hu, L. Debnath, Linear Partial differential equations for scientists and Engineers, Birkhauser.	
Learning Outcomes	Learns to solve partial differential equations of first and second order. Learns to model initial and boundary value problems. Analyses the properties of solution.	

Programme: M.Sc. Mathematics

Course Code: MTO-205 **Title of the Course: COMPLEX ANALYSIS**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Algebra of complex numbers including polar representation, Basics in Real Analysis including convergence series, Topology of the Complex/Real plane, Basic Complex Analysis including Cauchy,s theorem.
Objectives	This course will prepare a student to take up research in Complex Function Theory, Several Complex Variable Complex Analysis etc.
Contents	**1. Complex Differentiability**: Analytic Functions and Power series, Radius of convergence, Continuity and differentiability of power series, Existence of power series expansion, Exponential and Trigonometric function. — 12 hours **2. Contour Integration**: Recall Cauchy's theorem; Cauchy's integral formulae, Analyticity of Complex differentiable functions, Liouville's theorem, Fundamental theorem of Algebra, Mean value property and Maximum modulus principle. — 10 hours **3. Zeros and Poles**: Zeros and Poles of holomorphic functions, Singularities, Laurent series, Residues, winding number, The Argument principle. — 8 hours **4. Evaluation of Definite Real integrals**: Trigonometric integrals, Improper integrals, Bypassing a pole, Inverse Laplace transform, Branch cut and Key hole integrals. — 10 hours **5. Schwarz's lemma**: Schwarz's lemma. — 4 hours **6. Conformal maps**. — 4 hours
Pedagogy	Class room lectures and tutorials, assignments and library reference.
References	1. Anant R Shastri, Basic Complex Analysis of one variable, MacMillan, 2011.II edition 2. J B Conwey, Complex Analysis, Springer Verlag. 3. Churchill and Brown, Complex Analysis, 4. E.B.Saff, A.D.Snider ; Fundamentals of Complex Analysis. Pearson
Learning Outcomes	Students will be prepared to take up advanced complex analysis, complex analysis of more than one variable and will be equipped to take research in Complex Analysis and related subjects.

Programme: M.Sc. Mathematics
Course Code: MTO -206 **Title of the Course: MEASURE THEORY**
Number of Credits: 04
Effective from: June, 2018.

Prerequisites	Should have undergone a course in Real Analysis that includes Riemann Integration in one variable. Should be familiar with set theory very well.	
Objectives	To prepare students to handle Functional Analysis, Fourier series and their convergence, Laplace and Fourier transforms Wavelets analysis and Continuous probability theory.	
Contents	**1.Reimann-Stieltjes Integral**: Weights and measures, The Riemann-Steiltjes integral, Space of integrable functions, Integrators of bounded variation, The Riemann integral. Shortcomings of Riemann integration.	8 hours
	2.Lebesgue Measure: Lebesgue outer measure, Riemann integrability, Measurable sets, The structure of measurable sets, A non-measurable sets.	10 hours
	3.Measurable Functions: Measurable functions, Extended real valued functions, Sequence of measurable functions, Approximation of measurable functions.	8 hours
	4.The Lebesgue Integral: Simple functions, Non-negative functions, The general case, Lebesgue Dominated convergence theorem, Approximation of integrable functions.	12 hours
	5.Applications: The L^p spaces, Approximation of L^p-functions, Fourier series. Convergence in mean of the Fourier Series.	10 hours
Pedagogy	Class room lectures and tutorials, assignments and library reference.	
References	1. N L Carothers, Real Analysis, Cambridge University Press, 2006. 2.H L Royden, Real Analysis, PHI, 1995. 3.Charalambos D Aliprantis, Owen Burkinshaw, Principles of Real Analysis, Academic Press/Elsevier, 2004. 4.Paul Halmos, Measure Theory.	
Learning Outcomes	The course will prepare the students to take courses in functional analysis, Partial Differential equations etc. This enables the students to study Abstract measure theory and Probability theory.	

Programme: M. Sc. (Mathematics)

Course Code: MTO -207 **Title of the Course:** Number Theory

Number of Credits: 4

Effective from AY: 2018-19

Prerequisites for the course:	Some basic Complex Analysis. Elementary number theory. Congruences.	
Objective:	This course will serve as Prerequisites to an advanced Course in Analytical Number Theory.	
Content:	1. **Fundamental Theorem of Arithmetic.** Divisibility. Fibonacci numbers. 2. **Arithmetical functions and Dirichlet multiplication.** Mobius function μ. Euler totient function **φ**. Relation connecting μ and **φ**. Product formula for **φ** (n). Dirichlet product of arithmetical functions. Dirichlet inverse and Mobius inversion formula. Mangoldt function. Multiplicative functions. Liouville function. Divisor functions. Generalized convolutions. Formal power series. Derivative of arithmetical functions. 3. **Averages of arithmetical functions.** Big oh notation. Euler summation formula. Some elementary asymptotic formulas. Average order of d(n). Average order of $\sigma_\alpha(n)$. Average order of **φ** (n). Average order of μ(n) and Λ(n). 4. **Some elementary theorems on distribution of prime numbers.** 5. **Characters of finite abelian groups.** 6. **Partition Theory.** Partitions of numbers. Generating function of p(n). Other generating functions. Theorems of Euler. Theorem of Jacobi. Special cases of Jacobi's identity. 7. **Basic Cryptology.**	10 hours 10 hours 10 hours 6 hours 4 hours 6 hours 2 hours
Pedagogy:	lectures/ tutorials/assignments/self-study.	
References/Readings	1. T. M Apostol, *Introduction to Analuytic Number Theory*, Narosa Publishing House. 2. Thomas Koshy, *Elementary Number Theroy with Applications*, Second Edition, Elsevier India Pvt. Ltd., **2005**. (Chapter 9) 3. G.H. Hardy and E.M. Wright, Introduction to theory of numbers. (Chapter XIX) 4. Heng Huat Chan, *Analytic Number Theory for Undergraduates*, (Monographs in Number Theory), World Scientific, **2009**. 5. I. Niven, H.S. Zuckerman and H.L. Montgomery, *An Introduction to the Theory of Numbers*, 5th edition, Wiley-India. 6. David Burton, *Elementary Number Theory*, Sixth edition, Tata McGraw-Hill Edition. 7. A. Baker, A concise introduction to theory of numbers, Cambridge University Press. 8. J. Stillwell, Elements of Number Theory, Springer.	
Learning Outcomes	1.This course prepares the student to learn advanced number theory, Cryptography and Partition theory. 3. Taking this course students can read more advanced Analytic Number Theory books.	

Programme: M. Sc. (Mathematics)
Course Code: MTO -208 **Title of the Course:** Lie Algebra
Number of Credits: 4
Effective from AY: 2018-19

Prerequisites for the course:	Basic Linear Algebra, basic group theory, basic analysis.	
Objective:	This course develops concepts in Matrix Groups and Lie algebras. It helps in understanding other concepts like Manifold, Lie groups etc.	
Content:	1. **Matrix Groups.** Matrices. Real and Complex Matrix Groups. Orthogonal Groups. Topology of Matrix Groups. Tangent space.	12 hours
	2. Lie algebras. Definition, Some Examples, subalgebras and Ideals. Homomorphisms. Algebras. Derivations. Structure Constants. Ideals and Homomorphisms. Constructions with Ideals. Quotient Algebras. Correspondence between Ideals. Low-Dimensional Lie Algebras.	10 hours
	2. **Solvable Lie Algebras.** Nilpotent Lie Algebras. Subalgebras of gl(V). Nilpotent Maps. Weights. The Invariance Lemma. An Application of the Invariance Lemma.	8 hours
	3. **Some Representation Theory.** Modules for Lie Algebras. Submodules and Factor Modules. Irreducible and Indecomposable Modules. Homomorphisms. Schur's Lemma. Representations of sl(2,C). The Modules V_d . Classifying the Irreducible sl(2,**C**)-Modules.	8 hours
	4. **Brief introduction to: Cartan's Criteria.** Testing for Solvability. The Killing Form. Testing for Semisimplicity. Derivations of Semisimple Lie Algebras. The Root Space Decomposition. Cartan Subalgebras. Definition of the Root Space. Decomposition. Cartan Subalgebras as Inner-Product Spaces. Root Systems. Bases for Root Systems. Cartan Matrices and Dynkin Diagrams.	10 hours
Pedagogy:	lectures/ tutorials/assignments/self-study.	
References/Readings	1. Kristopher Tapp, *Matrix Groups for Undergraduates*, American Mathematical Society, **2005**. 2. Karin Erdmann and Mark J. Wildon, *Introduction to Lie Algebras* , Springer Undergraduate Mathematics Series, Springer-Verlag. **2006**. 3. J.E. Humphreys, *Introduction to Lie algebras and representation theory*, Graduate Text in Mathematics, Springer-Verlag. 4. N. Jacobson, *Lie Algebras*, Dover Publications. 5. J.-P. Serre, *Complex Semisimple Lie Algebras*, Springer.	
Learning Outcomes	1. Taking this course students get acquainted with Lie algebras and Matrix groups theory. 2. Taking this course student can read Lie groups theory.	

Programme: M. Sc. (Mathematics)
Course Code: MTO-209 **Title of the Course:** Special Functions
Number of Credits: 4
Effective from AY: 2018-19

Prerequisites for the course:	Some basic Complex Analysis and Differential Equations.	
Objective:	This course develops concepts in Gamma, Beta functions and also studies Legendre polynomials and Bessels functions.	
Content:	1. **Infinite products**:- Introduction, definition of an infinite product, a necessary condition for convergence, the associated series of logarithms, absolute convergence, uniform convergence. 2. **The Gamma and Beta functions**:- The Euler and Mascheroni constant, the Gamma function, a series for Γ'(z)/ Γ(z), evaluation of Γ(1) and Γ'(1), the Euler product for Γ(z), the difference equation Γ(z + 1) = zΓ(z), evaluation of certain infinite products, Euler's integral for Γ(z), the Beta function, the value of Γ(z) Γ(1 - z), the factorial function, Legendre's duplication formulae, Gauss' multiplication theorem, a summation formula due to Euler. 3. **The hypergeometric function**:- The function F(a,b; c; z), a simple integral form, F(a,b,c,1) as a function of the parameters, evaluation of F(a,b,c,1), the contiguous function relations, the hypergeometric differential equation, F(a,b,c,z) as a function of its parameters, elementary series manipulations, simple transformations. 4. **Series solution of differential equations**. Method of Frobenius. 5. **Legendre Polynomials and Functions**. Legendre equation and its solution. Generating function. Legendre series. Associated legendre functions. Properties of associated Legendre functions. 6. **Bessel function, Bessel's equatin and its solutions**. Generating function. Integral representation. Recurrence relations. Hankel functions. Equations reducible to Bessel's equation. Modified Bessels functions. Recurrence relations for modified Bessels functions.	6 hours 10 hours 8 hours 8 hours 8 hours 8 hours
Pedagogy:	lectures/ tutorials/assignments/self-study.	
References/Readings	1. E.D. Rainville, Special functions, Chelsa Publishing Company, New York, 1960. 2. W.W. Bell, Special Functions for scientists and engineers, Dover Publications, New York, 2004. 3. G.E. Andrews, R. Askey, R. Roy, Special .Functions, Encyclopedia of Mathematics and its Applications 71, Cambridge University Press, Cambridge.1999.	
Learning Outcomes	Taking this course students (i) get acquainted with Gamma, Beta functions. Also they study Legendre and Bessel Functions. (ii) can study some Engineering Mathematics.	

Programme: M.Sc. Mathematics

Course Code: MTO -210 **Title of the Course: DIFFERENCE EQUATIONS**

Number of Credits: 04

Effective from: June, 2018.

<table>
<tr><td>Prerequisites</td><td>Knowledge of basic Real Analysis, Linear Algebra and Differential equations..</td></tr>
<tr><td>Objectives</td><td>This course helps in understanding basic concepts of discrete calculus. It develops the ability to solve difference equations by standard methods. It will help students to take up further studies in discrete dynamical systems and numerical modeling.</td></tr>
<tr><td>Contents</td><td><table>
<tr><td>1. Calculus of finite differences: Review of basic concepts.</td><td>8 hours</td></tr>
<tr><td>2. Nonlinear Difference Equations. Equilibrium Points and their dynamics. Logistic equation.</td><td>8 hours</td></tr>
<tr><td>3. Linear difference equations. Basic theory. Method of Undetermined Coefficients and Variation of Parameters Formula. Higher Order equations. Behaviour of Solutions. Nonlinear equations transformable to linear equations</td><td>12 hours</td></tr>
<tr><td>4. Systems of linear Difference Equations. Basic Theory. Linear Periodic systems. Stability theory of Linear Systems.</td><td>12 hours</td></tr>
<tr><td>5. Z-Transforms and its applications. Volterra Difference Equation of Convolution Type.</td><td>8 hours</td></tr>
</table></td></tr>
<tr><td>Pedagogy</td><td>Lectures/ tutorials/assignments/self-study..</td></tr>
<tr><td>References</td><td><u>Main Texts:</u>
1 . S.N .Elaydi, An Introduction to Difference Equations, Springer Verlag.

<u>Reference texts :</u>
2. S.Goldberg , Introduction to Difference equations, Wiley Publication.
3. V.Lakshmikantham and D.Trigiante, Theory of difference equations, Academic Press.
4. K.Miller, Linear Difference equations, W.A.Benjam.</td></tr>
<tr><td>Learning Outcomes</td><td>1. Learn to solve difference equations.
2. Analyses the properties of solution.
3. Learns about discrete models and their stability</td></tr>
</table>

Programme: M.Sc. Mathematics

Course Code: MTO -301 **Title of the Course: ADVANCED ALGEBRA**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Knowledge of basic s in linear algebra and linear maps, group theory, ring theory including the polynomial rings over fields.
Objectives	This course will prepare a student to take up research in Field Theory, Number theory, Cryptography, etc.
Contents	**1.Extension of Fields**: Field extensions, Field of rational functions, Finite extension and Product rule of degrees, Simple extension, Algebraic extension, Transcendental extension, Construction by straight edge and compass, Constructible numbers. 12 hours **2.Splitting Field**: Roots of polynomial, Splitting field, Existence and uniqueness of splitting field, Isomorphism extension theorem, Algebraic closure, Existence and uniqueness of Algebraic closure, Finite fields, Existence and uniqueness of finite fields, Derivative and multiple roots, Simple extension, primitive roots of unity, Cyclotomic extensions. 10 hours **3.Automorphism group**: Automorphisms of fields, Galois groups, Galois groups of finite fields, Galois group of Cyclotomic extensions. Galois group of a polynomial. 8 hours **4.Galois Theory**: Symmetric rational functions, Galois group of field of rational function in *n* variable, Normal Extension, Fundamental Theorem of Galois theory. 10 hours **5.Solvability**: Solvable groups, Insolvability of A_5, Solvability of polynomials, Insolvability of quintics, Examples of insolvable quintics over $\mathbb{Q}$. 8 hours
Pedagogy	Class room lectures and tutorials, assignments and library reference.
References	1.I N Herstein, Topics in Algebra, Wiley Students Edition, 2006. 2.David S. Dummit and Richard M. Foote, Abstract Algebra, II Edition, John Wiley Sons Inc., 1999. 3.Thomas Gallian, Abstract Algebra,
Learning Outcomes	Students will be prepared to take up research in Algebra in general and Filed theory, Algebraic number theory and Cryptology in particular.

Programme: M. Sc. (Mathematics)
Course Code: MTO-302 **Title of the Course:** COMBINATORICS
Number of Credits: 4
Effective from AY: 2018-19

Prerequisites	Basics of - Set Theory , Algebra, Linear Algebra	
Objective	Starting from the basic principles of counting, this course aims to give an introductory exposition to different aspects of Combinatorics. The course will emphasise on the importance of enumeration tools and techniques in diverse branches of Mathematics and Applied fields.	
Content	**1.Basic Counting Principles and Techniques** Review of basic Counting Principles-Addition Principle, Multiplication Principle, Method of two-way Counting, Method of Bijections, Permutations and Combinations, Circular Permutations, Counting Objects with Repetitions, Binomial and Multinomial Theorems (Combinatorial Proofs), Binomial and Multinomial Coefficients and Identities. **2.The Fundamental Counting Problem** Statement of the Problem-The Sxteen Cases, Partition Numbers P(n,k) and P(n), Stirling Numbers S(n,k) and s(n,k), Bell numbers B(n). **3.Recurrence Relations and Explicit Formulas** The Inclusion-Exclusion Principle, Derangements and D(n), Recurrence Relations and Explicit Formulas for P(n,k),P(n), S(n,k), s(n,k), B(n), and D(n). Idea of Generating Functions , Method of solving Linear Recurrence Relations Using Generating Functions, Generating Functions for P(n,k), P(n), S(n,k), s(n,k), B(n) and D(n). **4.Pigeonhole Principle (PHP)** The Pigeonhoe Principle - its different formulations and examples, Applications of PHP to some standard Problems in Geometry, Number Theory , Graph Theory and Colouring of Plane. **5.Sequnces and Partial Orders** Applications of PHP to Sequences and Partial Orders- The Erdös-Szekeres Theorem, Dilworth's Lemma, Dilworth's Theorem, Sperner's Theorem. **6.Ramsey Theory** Ramsey's Theorem –First version (for 2 colours) , Second version (for r colours), and Infinitary version, Ramsey Numbers and bounds, Computations of small Ramsey Numbers, Schur's Theorem, van der Waerden's Theorem (Statement and Discussion).	12 Hours 2 Hours 12 Hours 6 Hours 6 Hours 10 Hours
Pedagogy	Lectures/ Tutorials/Assignments/Self-study	
References/ Readings	1. Introduction to Combinatorics, Martin J. Erickson, John Wiley,1996. 2. Cominatorial Techniques, Sharad S. Sane, Hindustan Book Agency, 2013. 3. Introducion to Combinatorics, W.D. Wallis and J.C. George, 2011. 4. A Walk Through Combinatorics, M. Bona, World Scientific Publishing Company, 2002. 5. Combinatorics, V.K. Balakrishnan, Schaum Series, McGraw-Hill,	
Learning Outcomes	Students ,on completion of this course, • Will be able to appreciate the importance of combinatorial techniques in diverse branches of Mathematics and Applied fields. • This course will teach the students how to understand and deal with enumerative problems and to apply combinatorial techniques to solve a range of application problems in Optimization, Graph Theory and Networking.	

Programme: M.Sc. Mathematics

Course Code: MTO -303 **Title of the Course: DIFFERENTIAL GEOMETRY**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Should have undergone basic courses in Real Analysis, Calculus of Several Variables, Linear Algebra and Vector calculus. Knowledge of metric space theory, topology and Partial differential equations are desirable.
Objectives	To prepare students to take up a research career in modern Geometry/Topology.
Contents	**1.Curves**: Regular curves in space, arc-length, parameterization, arc-length parameterization. 6 hours **2.Curvature**: Curvature and torsion of space curves, Serret-Frenet formula, Signed curvature of plane curves, Periodic curves, Simple closed curves, Isoperimetric inequality and Four-vertex theorem. 8 hours **3.Surfaces in 3-dimention**: Regular surfaces in 3-dimension, Tangents space, Normal and Orientation, Quadric surfaces. 7 hours **4.First Fundamental Form**: The First fundamental form of a regular surface, Length of arcs on surfaces, Area of surfaces, isometries and conformal mappings of surfaces. 9 hours **5.Second Fundamental Form**: Second fundamental for of a surface, normal curvature of a surface and principal curvatures of a surface. 10 hours **6.Gaussian Curvature**: Mean and Gaussian curvatures of a surface, Surfaces of constant curvatures, pseudo sphere, Gauss map. 8 hours
Pedagogy	Class room lectures and tutorials, assignments and library reference.
References	1. Andrew Pressley, Differential Geometry, Springer Verlag,
Learning Outcomes	Prepare the students to take up research in mathematics, in particular, in Geometry and Topology.

Programme: M.Sc. Mathematics

Course Code: MTO -304 **Title of the Course: Mathematical Modeling**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Knowledge of basic Real Analysis, Advanced Calculus, Ordinary and Partial Differential equations, Difference equation.	
Objectives	This course develops the understanding of purpose and importance of mathematical modeling.	
Contents	1. Introduction, Classification, Techniques and Examples of mathematical modeling. Modeling process with proportionality and geometric similarity.	16 hours
	2.Mathematical Modeling through ordinary differential equations of first order and of second order. First order systems of ordinary differential equations.	16 hours
	3. Modeling with discrete dynamical systems.	16 hours
	4. Modeling through Partial differential equations.	16 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References	**Main Texts:** 1 . J.N.Kapur, A Mathematical Modelling, Wiley Eastern ltd. 2. F.R.Giordano, M.D.Weir, W.P.Fox, A first course in Mathematical modeling, Thomson Publications. **Reference texts :** 3. D.N.Burghes, Modelling with Differential Equations, Ellis Horwood and John Wiley. 4. J. Sandefur, Elementary Mathematical Modeling, Thomson Publications. 5. F.Chorlten, Differential and difference equations., Von Nostqand.	
Learning Outcomes	Students will learn to build up models using differential and difference equations and to analyse the behaviour of the given system analytically and numerically.	

Programme: M.Sc. Mathematics

Course Code MTO -305 **Title of the Course: INTEGRAL EQUATIONS**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Knowledge of Real Analysis, Linear Algebra, Differential equations, Several variable calculus.	
Objectives	This course helps in understanding basic concepts of Integral Equations. It develops the ability to solve integral equations by standard methods.	
Contents	1. Basic concepts of Integral equations. Classification. Integral Equations with Separable Kernels. Method of Successive Approximations. Resolvent Kernel and its Properties. Decomposition methods.	16 hours
	2. Applications to Ordinary Differential Equations, Initial Value Problems and Boundary Value Problems, Green's functions.	10 hours
	3. Classical Fredholm Theory. Symmetric Kernels, Hilbert-Schmidt Theory.	12 hours
	4. Singular Integral Equations, Abel and Cauchy Type and Hilbert Kernel. Integral Transform Methods (Laplace, Fourier and Hilbert).	10 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References	**Main Texts:** 1 . Ram P Kanwal, Linear Integral Equations, Theory and applications. Springer. **Reference texts :** 2. Courant and Hilbertt, Methods of Mathematical Physics, Vol. I. 3. S.G.Mikhilin, Integral Equations. 4. I.G.Petrovsky, Lectures on the theory of Integral equations. 5. K.Yoshida, Lectures on Differential and Integral Equations	
Learning Outcomes	Students will learn to solve Integral equations by different methods. .	

Programme: M.Sc. Mathematics

Course Code: MTO -306 **Title of the Course: STURM LIOUVILLE PROBLEMS**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Knowledge of Real Analysis, Calculus of Several Variables, Complex analysis, Ordinary differential equations, Methods of Applied Mathematics	
Objectives	This course develops the ability to solve Sturm Liouville problems. These problems are encountered in mathematical Physics.	
Contents	1.Review of ordinary differential equations. Principle of Superposition, Boundary Conditions. Adjoint Equation. Green"s Formulae. Vibrating String.	16 hours
	2.Sturm Liouville problems. Singular Boundary Points. Asymptotic Behaviour.	14 hours
	3.Eigen value problems with continuous spectra.	10 hours
	4.Suspended Rope and Associated Integral equation.	8hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References	**<u>Main Texts:</u>** 1. M.P.S. Estham, Theory of differential equations, Van Nostrand, 1970. **<u>Reference texts :</u>** 1.R.Courant , D.Hilbert. Methods of Mathematical Physics, Vol. I Wilay Eastern, New Delhi,1975. 2.. Coddington E. and Levinson, Theory of ordinary differential equations, TMH.	
Learning Outcomes	Learns to form and solve SLP..	

Programme: M.Sc. Mathematics

Course Code: MTO -307 **Title of the Course: MATHEMATICS FOR FINANCE**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Knowledge of basic Real Analysis, Differential equations, Elementary Probability theory.	
Objectives	This course helps in understanding basic concepts of Financial mathematics and in understanding financial models.	
Contents	1.Introduction. A simple market model. Rates of interests. Present value. No Arbitrage Principle. Risk and Returns. Risk free assets.	12 hours
	2. Time value of money and money market. Risk assets. Dynamics of stock prices. Tree and other models. Binomial tree model. Discrete time market model.	12 hours
	3. Portfolio Management. Securities.	10 hours
	4. Contracts. Options. Types and bounds. Forward options. Call and put options. Variable interest rates.	14 hours
Pedagogy	Lectures/ tutorials/assignments/self-study.	
References	**<u>Main Texts:</u>** 1. Marek Capinski and T.Zastawnik , Mathematics For Finance, Springer Verlag, 2003. (Chap. 1-7; 10) **<u>Reference texts :</u>** 2. Damiano Brigo, Fabio Mercurio Interest rates models Theory and Practice, Springer. 3. Alexander Melinkov Risk Analysis in Finance and Insurance, Chapman \& Hall. 4. An elementary introduction to Mathematical Finance, Sheldon Ross	
Learning Outcomes	1. Learns the basics of Financial computations 2. Understands the working of financial market. .	

Programme: M.Sc. Mathematics

Course Code: MTO-401 **Title of the Course: ADVANCED LINEAR ALGEBRA**

Number of Credits: 04

Effective from: June, 2018.

Prerequisites	Linear spaces, dimension, Linear maps, eigenvalue problem, Algebraically closed fields, Fundamental theorem of Algebra, Multivariable Calculus, Reimann Integration of multivariable functions.
Objectives	To prepare students to handle solving problems involving linear equations and take up research in such areas.
Contents	**1.Elementary Decomposition**: Characteristic values, Annihilating polynomials, Invariant subspaces, Simultaneous triangulation and diagonalization, Invariant Decompositions, Primary Decomposition. 14 hours **2.Rational and Jordan forms**: Cyclic subspaces and Annihilators, Cyclic decomposition and Rational forms, Jordan forms, Computation of Invariant factors. 16 hours **3.Multi-linear Algebra**: Multi-linear functions and forms and tensors, Alternating forms and alternating products, Determinant function, Permutations and uniqueness of determinant, Properties of determinant, Differential Forms, Integration on Chains, Poincare lemma and Stoke's theorem. 18 hours
Pedagogy	Class room lectures and tutorials, assignments and library reference.
References	4.Kenneth Hoffman, Linear Algebra, PHI, 1997. 5. James Munkres, Calculus on Manifolds, 6. Spivak, Calculus on Manifolds,
Learning Outcomes	Students will be equipped to study Differential geometry, Differential Topology, Representation theory of groups and also to take up research in various areas of mathematics and Statistics.

Programme: M. Sc. (Mathematics)

Course Code: MTO-402 **Course Title:** COMMUTATIVE ALGEBRA

Number of Credits: 4

Effective from AY: 2018-19

Prerequisites	A first course in Algebra with Groups , Rings and Fields	
Objective	To introduce students to Commutative algebra and develop concepts in higher algebra with adequate examples and counter examples.	
Content	**1.Modules** Definition, Direct Sums, Free Modules and Vector Spaces, Quotient modules, Homomorphisms, Simple Modules, Modules over PID's. **2.Modules with Chain Conditions** Artinian Modules and Rings, Noetherian Rings and Modules, Modules of Finite Length, Nil Radicals and Jacobson Radicals, Radical of an Artinian Ring. **3.Homological Algebra** Chain Complexes, Exact Sequences, Five Lemma and Snake Lemma, homology Group of a Chain Complex, Long Exact Sequence associated with Exact Sequences of Chain Complexes	16 Hours 20 Hours 12 Hours
Pedagogy	Lectures/ Tutorials/Assignments/Self-study	
References/ Readings	1. Introduction to Rings and Modules, C. Musili, Narosa Publishing House, 1992. 2. Algebra, S. Lang, Addison Wesley, 1985. 3. Commutative Algebra, N. S. Gopalakrishnan, Universities Press, 2015. 4. A First Course in Abstract algebra, J.B.Fraleigh, Pearson, 2002.	
Learning Outcomes	A student completing this course will have • Basic knowledge and understanding of Module Theory and Homological algebra • Ability to solve problems related to the content of the course • Foundation to take up further studies in Commutative Algebra and Algebraic Geometry	