CURRICULUM & SYLLABUS

CHOICE BASED CREDIT SYSTEM (CBCS)

FOR

MASTER OF SCIENCE (M.Sc.)

(2 Year Postgraduate Degree Programme)

IN

MATHEMATICS

[w. e. f. 2020-21]

FACULTY OF SCIENCE & HUMANITIES
SRM UNIVERSITY DELHI-NCR, SONEPAT
Plot No.39, Rajiv Gandhi Education City, P.S. Rai, Sonepat
Haryana-131029

SRM UNIVERSITY DELHI-NCR, SONEPAT (HARYANA)

VISION

SRM University Haryana aims to emerge as a leading World Class Institution that creates and disseminates knowledge upholding the highest standards of instruction in Engineering & Technology, Science & Humanities, Commerce, Management, Hotel Management & Medicine & Health Science. Along with academic excellence, our curriculum imparts integrity and social sensitivity so that our graduates may best serve the Nation and the World.

MISSION

- To create a diverse community campus that inspires freedom and innovation.
- Strengthen Excellence in educational & skill development processes
- Continue to build productive international alliances
- Explore optimal development opportunities available to students and faculty
- Cultivate an exciting and rigorous research environment

DEPARTMENT OF MATHEMATICS

VISION

The Department of Mathematics strives:

- To foster experimental, problem-oriented and discovery learning of mathematics.
- Designing a mathematics phobia through authentic learning based on hands-on experience with computers
- To provide greater scope for individual participation in the process of learning and becoming autonomous learners.
- To provide scope for greater involvement of both the mind and the hand which facilitates cognition?
- To ultimately see that the learning of mathematics becomes more alive, vibrant, relevant and meaningful; a program that paves the way to seek and understand the world around them. A possible by-product of such an exercise is that math-phobia can be gradually reduced amongst students.
- To help the student build interest and confidence in learning the subject.

MISSION

The Department of mathematics offers the course:

- To get students started to enjoy mathematics, solve abstract problems and use abstraction to understand relationships and structure, and to understand the basic structure of mathematics
- To Increase retention of mathematical concepts in the student.
- To develop a spirit of inquiry in the student.
- To improve the perspective of students on mathematics as per modern requirement.
- To enable the teacher to display, explain and reinforce abstract mathematical ideas using solid objects, models, charts, graphs, diagrams, posters with the help of FOSS tools on the computer.
- To make the learning process student-friendly by having a change in focus in mathematical teaching, especially in the mathematical learning environment.
- To exploit techno-savvy nature in the student to overcome math-phobia.
- To set up a matlab to help students discover mathematical concepts through activities and experimentation.

PROGRAM REQUIREMENT

Advanced Science Requirements: Computer Sciences (CS) through regular/online mode.

Disciplinary Requirements comprising of:

Department of Mathematics	Core courses (through regular/online mode)
Department of Mathematics	Electives (through regular/online mode)

Practical and Research component:

1. Regular Practical and Research
2. Minor and Major Project

SEMESTER-I

Code	Category	Course	L	T	P	C
Theory						
20MAT 0101	Core	Abstract Algebra	3	1	0	3
MAT 0102	Core	Real Analysis	3	1	0	3
MAT 0103	Core	Complex Analysis	3	1	0	3
20MAT0104	Core	Ordinary Differential Equations	3	1	0	3
	DE	Department Elective –I	3	1	0	3
Practical						
20MAT0106L		C++ Programming Lab	0	0	2	1
Total			12	4	2	
Total Contact Hours			30			

SEMESTER-II

Code	Category	Course	L	T	P	C
Theory						
20MAT 0208	Core	Linear Algebra	3	1	0	3
20MAT 0202	Core	Numerical Analysis	3	1	0	3
MAT 0203	Core	Discrete Mathematics	3	1	0	3
MAT 0204	Core	Integral Equations and Calculus of Variations	3	1	0	3
	DE	Department Elective –II	3	1	0	3
Total			15	5	0	15
Total Contact Hours			20			

SEMESTER-III

Code	Category	Course	L	T	P	C
Theory						
MAT 0301	Core	Topology	3	1	0	3
MAT 0302	Core	Partial Differential Equations	3	1	0	3
MAT 0303	Core	Operations Research	3	1	0	3
	DE	Department Elective –III	3	1	0	3
	DE	Department Elective –IV	3	1	0	3
Total			15	5	0	15
Total Contact Hours			20			

SEMESTER-IV

Code	Category	Course	L	T	P	C
Theory						
MAT 0401	Core	Functional Analysis	3	1	0	3
MAT 0402	Core	Research Methodology	3	1	0	3
MAT 0403	Core	Project	0	0	0	12
	DE	Department Elective –V	3	1	0	3
	DE	Department Elective –VI	3	1	0	3
Total			15	5	0	15
Total Contact Hours			20			

SUMMARY OF CREDITS

Category	I Sem	II Sem	III Sem	IV Sem	Total	%
Core	12	12	9	18	51	73.91
DE	3	3	6	6	18	26.09
Total	15	15	15	24	69	100

EVALUATION SCHEME

INTERNAL EVALUATION (THEORY)

Assessment	Internal Assessment-I	Internal Assessment-II	Internal Assessment-III	Internal Assessment-IV	Internal Assessment-V	Total
Marks	10	10	10	10	10	50

INTERNAL EVALUATION (PRACTICAL)

Assessment	Daily Assessment/Observation	Programs performed during Lab hours	Programs performed during Internal practical Examinations	ViVa- Voce	Total
Marks	10	10	15	15	50

EXTERNAL EVALUATION (THEORY)

Assessment	End Semester Examination	Total
Marks	100	Will be scaled in 50

EXTERNAL EVALUATION (PRACTICAL)

Assessment	Record File	Programs performed during External Practical Examinations	Written Work	Viva- Voce	Total
Marks	10	10	15	15	50

Note:

1. The evaluation Scheme may change as per the university guidelines.
2. Evaluation scheme of Industrial training may vary department wise.
3. Evaluation scheme project/minor project may vary department wise.
4. Department are advised to add the evaluation scheme in their respective curriculum.

PROGRAM OBJECTIVE

The objectives of the M.Sc. Mathematics program is to develop students with the following capabilities:

1. To Provide knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in other scientific and engineering domains
2. To provide students with advanced mathematical and computational skills that prepares them to pursue higher studies and conduct research.
3. To motivate the students for research studies in mathematics and related fields.
4. To provide students with a knowledge, abilities and insight in Mathematics and computational techniques so that they are able to work as mathematical professional.
5. To provide students with knowledge and capability in formulating and analysis of mathematical models of real life applications.

PROGRAM OUTCOME

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After successful completion of this program, the students will be able to:

1. Apply knowledge of Mathematics, in all the fields of learning, including higher research and its extensions.
2. Carry out development work as well as take up challenges in the emerging areas of the Industry.
3. Demonstrate competence in using mathematical and computational skills to model, formulate and solve real life applications.
4. Crack lectureship and fellowship exams approved by UGC like CSIR – NET and SET/ ISRO/DRDO.

LIST OF MODULE ELECTIVES

Code	Category	Course	L	T	P	C
Departmental Elective-I (Any one of the following)						
MAT 0105	Core	Transform techniques with applications	3	1	0	3
20MAT0106	Core	Programming in C++	3	1	2	4
MAT 0107	Core	Financial Mathematics	3	1	0	3
Departmental Elective-II(Any one of the following)						
MAT 0205	Core	Probability and Statistics	3	1	0	3
MAT0207	Core	Fuzzy Set Theory	3	1	0	3
MAT 0201	Core	Number Theory	3	1	0	3
Departmental Elective-III (Any one of the following)						
MAT 0304	Core	Fluid Dynamics	3	1	0	3
MAT 0305	Core	Mathematical Methods	3	1	0	3
MAT 0306	Core	Statistical Inference	3	1	0	3
Departmental Elective-IV (Any one of the following)						
MAT 0307	Core	Mechanics	3	1	0	3
MAT 0308	Core	Mathematical Programming	3	1	0	3
20MAT0310	Core	Mathematical Biology	3	1	0	3
Departmental Elective-V(Any one of the following)						
20MAT0404	Core	Modeling and Simulation	3	1	0	3
MAT 0405	Core	Algebraic Topology	3	1	0	3
20MAT0406	Core	MATLAB	3	1	0	3
Departmental Elective-VI(Any one of the following)						
MAT0407	Core	Differential Geometry	3	1	0	3
MAT0408	Core	Stochastic Process	3	1	0	3
MAT0409	Core	Computing with R	3	1	0	3

SEMESTER I

Course Code	Subject Name	L	T	P	C
20MAT 0101	**Abstract Algebra**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course aims to familiarize the learner with Conjugates and centralizers in Sn, p-groups,Applications of Sylow theorems, Normal and subnormal series, Modules, Cyclic modules,Noetherian and Artinian modules.

UNIT	Course contents	Contact Hours
Unit-I	Conjugates and centralizers in Sn, p-groups, Group actions, Counting orbits. Sylow subgroups, Sylow theorems, Applications of Sylow theorems, Description of group of order p2 and pq, Survey of groupsupto order 15.	10
Unit-II	Normal and subnormal series, Solvable series, Derived series, Solvable groups, Solvability of Sn-the symmetric group of degree $n \geq 2$, Central series, Nilpotent groups and their properties, Equivalent conditions for a finite group to be nilpotent, Upper and lower central series. Composition series, Zassenhaus lemma, Jordan-Holder theorem	10
Unit-III	Modules, Cyclic modules, Simple and semi-simple modules, Schur lemma, Free modules, Torsion modules, Torsion free modules, Torsion part of a module, Modules over principal ideal domain and its applications to finitely generated abelian groups.	10
Unit-IV	Noetherian and Artinian modules, Modules of finite length, Noetherian and Artinian rings, Hilbert basis theorem. HomR(R,R), Opposite rings, Wedderburn – Artin theorem, Maschk theorem, Equivalent statement for left Artinian rings having non-zero nilpotent ideals. Radicals: Jacobson radical, Radical of an Artinian ring.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Apply group theoretic reasoning to group actions.
- Learn properties and analysis of solvable & nilpotent groups, Noetherian & Artinian modules and rings.
- Apply Sylow's theorems to describe the structure of some finite groups and use the concepts of isomorphism and homomorphism for groups and rings.
- Use various canonical types of groups and rings- cyclic groups and groups of permutations, polynomial rings and modular rings.

- Analyze and illustrate examples of composition series, normal series, and subnormal series.

Learning Resources	
Text Book	N. Herstein, Topics in Algebra, John Wiley & Sons. 2nd edition 2006
Reference Book and other materials	1. Surjeet Singh &QaziZameeruddin, Modern Algebra, Vikas Publications., 8th edition 2006. 2. D. A. R. Wallace, Groups, Rings and Fields, Series, Springer Undergraduate Mathematics Series, 1st Edition 2004. 3. N. H. McCoy, Theory of Rings, Chelsea Pub. Co., 1973. 4. Hoffman &Kunze, Linear Algebra, PHI, 2nd edition 2015. 5. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra, Cambridge University Press,2nd Edition 1994, Indian Edition, Online publication 2012.

Course Code	Subject Name	L	T	P	C
MAT 0102	**Real Analysis**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course gives the knowledge of basic properties of the field of real numbers, sequence and series of function and its convergence, concepts related to continuity and differentiability. Also includes Reimann-Stieltjes integral and concept of Lebesgue measure.

UNIT	Course contents	Contact Hours
Unit-I	Sequences and series of functions, point-wise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence, uniform convergence and continuity, uniform convergence and Riemann-Stieltjes integration, uniform convergence and differentiation.	10
Unit-II	Explicit and Implicit Functions, continuity, differentiability, partial derivatives, of higher orders, and equality, differentials of higher order, functions of functions, Taylor's theorem.	10
Unit-III	Definition and existence of Riemann-Stieltjes integral, properties of the integral, integration and differentiation, the fundamental theorem of Calculus, integration of vector-valued functions, rectifiable curves.	10
Unit-IV	Set functions, intuitive idea of measure, elementary properties of measure, measurable sets and their fundamental properties, Lebesgue measure of sets of real numbers, algebra of measurable sets, Borel sets, equivalent formulation of measurable sets in terms of open, closed F_s and G_d sets, non measurable sets.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Know the sequence and series of functions and their convergence.
- Apply Cauchy Criterion,Weierstrass M-test, Abel's and Dirichlet's tests.
- Know Fundamental Theorem of Calculus.
- Learn about Reimann-Stieltjes integral and its properties.
- Understand the concept ofLebesgue measure.

Learning Resources	
Text Book	W. Rudin, Principles of Mathematical Analysis McGraw-Hill, 4th edition, 2017
Reference Book and other materials	1. T.M.Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 2nd Edition, 1996. 2. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration,Published by Anshan Ltd,2nd Edition, 2012. 3. H.L. Royden, Real Analysis, Macmillan Pub. Cop. Inc, New York,4th Edition, 2010.

Course Code	Subject Name	L	T	P	C
MAT 0103	**Complex Analysis**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course aims to familiarize the learner with complex function theory, analytic function theory, the concept of Complex Integration and Cauchy's theorems, integral formulas, Transformation, singularities and contour integrations and finally provide a glimpse of MittagLeffler's expansion theorem.

UNIT	Course contents	Contact Hours
Unit-I	Functions,limlit and continuity,Cauchy Riemann equations, Necessary and sufficient conditions for a function to be analytic,Polar form of Cauchy Riemann equations, Harmonic function,Construction of analytical function, Power series, Radius of convergence of power series, Sum function of power series,CauchyHadamard theorem.	10
Unit-II	Complex Integration, Antiderivatives, Cauchy-Goursat Theorem, Simply and Multiply connected domains, Cauchy's Integral formula, Cauchy's Integral formula for higher Order derivatives, Morera's theorem, Cauchy's inequality, Liouville's theorem, The fundamental theorem of Algebra, Maximum Modulus Principle, Minimum Modulus Principle,Schwarz Lemma, Poisson's integral formula.	10
Unit-III	Transformation: Jacobian Transformation, Conformal Transformation, Some general transformations, bilinear transformations and their properties and classification.	10
Unit-IV	Taylor's Series, Laurent's Series, Singularities, Meromorphic functions, Argument principle, Rouche'stheorem,Calculus of residues, Cauchy's residue theorem, Evaluation of Integrals, MittagLeffler's expansion theorem.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Define continuity and differentiability of complex functions.
- Prove the Cauchy-Riemann equations and apply them to complex functions in order to determine whether a given continuous function is complex differentiable.
- Compute the radius of convergence for complex power series.

- Evaluate integrals along a path - directly from the definition and also via the Fundamental Theorem of Contour Integration and Cauchy's Theorem.
- Compute the Taylor and Laurent expansions of simple functions, determining the nature of the singularities and calculating residues.

Learning Resources	
Text Book	H.A. Priestly, Introduction to Complex Analysis, Clarendon Press Oxford, 2^{nd} Edition, 2008.
Reference Book and other materials	1.J.B. Conway, Functions of one Complex variable, Narosa Book Distributors Pvt Ltd-New Delhi, 2^{nd}Edition, 1996. 2. L.V. Ahlfors, Complex Analysis,Prentice-Hall of India Pvt.Ltd, 2015. 3.Mark J.Ablowitz and A.S. Fokas,Complex Variables: Introduction and Applications, Cambridge University Press,2003. 4.S. Ponnusamy, Foundations of Complex Analysis,Narosa Book Distributors, 2011. 5.J.W. Brown and R.V. Churchill, Complex Variables and Applications, MC Graw Hill, 9^{th}edition, 2013.

Course Code	Subject Name	L	T	P	C
20MAT 0104	**Ordinary Differential Equations**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course aims to familiarize the learner with various methods for solving ordinary differential equations with series solution. This module provides the knowledge ofthe Sturm separation theorem,Sturm's comparison theorem,Existence and uniqueness theorem. Also introduceboundary value problems and Green’s function.

UNIT	Course contents	Contact Hours
Unit-I	Introduction to Differential Equations: Formation of differential equations. Basic definitions (linearity, order, homogeneous and nonhomogeneous, explicit and implicit solution, general solution, particular solution). Existence and uniqueness theorem for linear ODE. Review of the first order ODE: Separable equations, ODE with homogenous coefficients. Exact equations. Integrating factors. ODE with linear coefficients, Bernoulli equation.	10
Unit-II	Second order linear equations: The general solution of the homogeneous equations, Use of a known solution to find another solution, Homogeneous equations with constantcoefficients, method of undetermined coefficients, method of variation ofparameters, Qualitative Properties of solutions of ordinary differential equations of order two: Sturm separation theorem, Normal form, Standard form, Sturm's comparison theorem,Existence and uniqueness theorem.	10
Unit-III	Power Series solutions: Review of power series, Series solutions of first orderequations, second order linear equations, Ordinary points, Regular singular points,Indicial equations, Gauss's Hyper geometric equation, and the point at infinity,Bessel functions.	10
Unit-IV	Systems of first order equations: General remarks on systems, linear systems,Homogenous linear systems with constant coefficient,Boundary Value Problems: Sturm-Liouville Boundary Value Problem, Green’s Function to solve boundary value problem.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Distinguish between linear, nonlinear, partial and ordinary differential equations.
- Solve second order linear equations by various methods.

- Solve equations by Power series solution
- Know systems of first order equations, linearsystems,Homogenous linear systems with constant coefficient.
- Solve boundary value

Learning Resources	
Text Book	S.L. Ross, Differential Equations, John Wiley and Sons, 2004.
Reference Book and other materials	1. George Simmons Differential equations with applications and Historical Notes, McGraw Hill Education; 2 edition, 2017. 2. M. D. Raisinghania, Advanced Differential Equations, S. Chand, 2012 3. .E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India Learning Private Limited, 1989. 3.S.G. Deo, V. Raghavendra, RasmitaKar,Textbook of Ordinary Differential Equations, McGraw Hill Education; Third edition, 2017.

SEMESTER II

Course Code	Subject Name	L	T	P	C
20MAT0208	**Linear Algebra**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

This course provides the knowledge of vector spaces and linear transformations .This also demonstrates an understanding of the relationship of linear algebra and Matrices.

UNIT	Course contents	Contact Hours
Unit-I	Vector Spaces, Subspaces, Sum and Direct Sum of subspaces, Linear combinations and subspaces spanned by a set of vectors, Linear dependence and Linear independence, Spanning Set and Basis, Finite dimensional spaces, Dimension	10
Unit-II	Linear transformations, linear operators, Properties of Linear Transformation, Algebra of Linear Transformation, Vector space isomorphism Range and null space of linear transformation, Rank and Nullity Theorem.	10
Unit-III	Matrix of a linear transformation, Singular and non-singular linear transformation, Minimal Polynomial, Eigen Values and Eigen Vectors, Algebraic multiplicity, Eigen spaces and geometric multiplicity Diagonalization criterion, diagonalizing matrix, Dual space, Anhilator, Annihilating polynomials	10
Unit-IV	Inner product spaces, Norm of a vector, Cauchy Schwarz inequality, normed linear space, orthogonal vectors and orthogonal complement, orthogonal projections, orthonormal set, Bessel's inequality, Gram-Schmidt orthogonalization process.	10

LEARNING OUTCOME:

Upon completing this course, students will able to:

- Understand the notion of a vector space and linear transformation.
- Determine basis and dimension of a vector space.
- Find the characteristic polynomial and characteristic roots of a square matrix.
- Know Diagonolization of the matrix
- Understand minimal polynomial and annhilators
- Compute an orthogonal basis using the Gram-Schmidt process.

Learning Resources	
Text Book	J.N. Sharma and A.R. Vasistha, Linear Algebra, Krishna PrakashanMandir, Meerut, 1st Edition, 2015.
Reference Book and other materials	1.Shanti Narayana, A Book of Matrices, S. Chand & Company Pvt. Ltd., New Delhi, 2013. 2.GilbertStrang and Kunze, Linear Algebra, Pearson, 5th Edition, 2016. 3.Stephen H. Friedberg et al, Linear Algebra, Prentice Hall of India Pvt. Ltd. 4th Edition, 2007

Course Code	Subject Name	L	T	P	C
20MAT 0202	**Numerical Analysis**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The objectives of studying this module are to make the students familiarize with the ways of solving complicated mathematical problems numerically. The course givesan understanding of the several errors and approximation in numerical methods. Also explains the several available methods to solve the simultaneous equations. The learner will study about the interpolation, numerical differentiation, integration, curve fitting and solution of ordinary differential equations.

UNIT	Course contents	Contact Hours
Unit-I	Errors in computation: Floating point representation ofnumbers, Significant digits, Rounding and chopping a number and error absolute and relative errors, Truncation error, Solution of Algebraic and Transcendental equations: Bisection method, Regula-Falsi method and Newton Raphson method. Linear equations-Gauss elimination method, LU Decomposition method, Gauss–Jordan method, Tridiagonal system, Gauss-Jacobi method, Gauss-Seidalmethod, Inversion of Matrix	10
Unit-II	Interpolation,Some operators and their properties, Finite difference table, Newton forward and backward Difference formulae, Gauss forward and backward formulae, Stirling's and Bessel formulae, Lagrange's method, Divided differences and Newton's divided difference formula.	10
Unit-III	Eigenvalue, Least squares method, curve fitting, Numerical differentiation and integration-Differentiation methods based on Newton's forward and backward formulae, Differentiation by central difference formula, Integration-Methodology of numerical integration, Rectangular rule, Trapezoidal rule,Simpson's$1/3^{rd}$ and $3/8^{th}$ rules, Gauss-Legendre quadrature formula.	10
Unit-IV	Ordinary differential equations: Initial and boundary value problems, Solutions of Initial Value Problems, Picard's method, Taylor's method, Single and multistep methods, Euler's and Modified Euler's method, Runge-Kutta second order method and fourth order, Milne's method, Adams-Bashforth method, Numerical solution of partial differential equations.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Demonstrate understanding of common numerical methods and how they are used to obtain approximate.
- Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration
- Find the solution of linear and nonlinear equations, and the solution of differential equations.

Learning Resources	
Text Book	M.K.Jain, S.R.K.Iyengar, R.K.Jain, Numerical Methods for Scientific and Engineering Computations, New Age International (P) Ltd., 6th edition, 2012.
Reference Book and other materials	1.B. S. Grewal, Numerical Methods in Engineering & Science with Programs in C, C++ &MATLAB, Khanna Publishers, 2014 2.James B. Scarborough, Numerical Mathematical Analysis, Oxford &Ibh Publishing Co. Pvt Lt 3.S. S. Sastry, Introductory methods of numerical analysis. PHI Learning Pvt. Ltd., 2012.

Course Code	Subject Name	L	T	P	C
MAT 0203	**Discrete Mathematics**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course aims to introduce recurrence relations and the method of generating functions, Pigeonhole Principle, lattices and their properties. The module includes the basics of Boolean algebra, Graphs and trees.

UNIT	Course contents	Contact Hours
Unit-I	Recurrence Relations, Explicit Formula for a Sequence, Solution of Recurrence Relations Homogeneous Recurrence Relations with Constant Coefficients, Particular Solution of a Difference Equation, Recursive Functions, Generating Functions, Convolution of Numeric Functions, Solution of Recurrence Relations by the Method of Generating Function.	10
Unit-II	The Pigeonhole Principle, Partially Ordered Sets, Hasse Diagram, and Logics: Basic Logical Operations, Logical Equivalence Involving Tautologies and Contradictions, Conditional Propositions, Quantifiers, Lattices: Properties of Lattices, Lattices as Algebraic System, Lattice Isomorphism, Bounded, Complemented and Distributive Lattices.	10
Unit-III	Definitions and Basic Properties of Boolean Algebra, Representation Theorem, Boolean Expressions, Logic Gates and Circuits, Boolean Function, Method to find Truth Table of a Boolean Function, Karanugh map, Expressing Boolean Functions as Boolean Polynomials, Addition of Binary Digits, Half – Adder, Full Adder.	10
Unit-IV	Graphs, Basic concepts and types of Graphs, Paths and Circuits, Eulerian Circuits, Hamiltonian Circuits, Matrix Representation of Graphs, Planar Graphs, Trees: Definition, and Characterization of Trees Representation of Algebraic Expressions by Binary Trees, Spanning Tree of a Graph, Shortest Path Problem, Minimal Spanning Tree, Tree Searching.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Formulate and interpret statements presented in Boolean logic.
- Apply truth tables.

- Know Tautologies and Contradictions.
- Know graphs and their types.
- Find Minimal Spanning Tree.

Learning Resources	
Text Book	B.Kolman,R. Busby, and S.C.Ross., Discrete Mathematical Structure, 6th Ed.,Pearson's Publication,2017.
Reference Book and other materials	1.C.L. Liu, Elements of Discrete Mathematics,Tata McGraw Hill, 4thedition,2017. 2.R.Johnsonbaugh, Discrete Mathematics, Maxwell Macmillan International, 7th Ed. 2015. 3.KenethH.Rosen, Discrete Mathematics and its application,TataMcgraw Hill, 7th edition 2017.

Course Code	Subject Name	L	T	P	C
MAT 0204	**Integral Equations and Calculus of Variations**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

This course aims to impart analytical ability in solving variational problems and Integral equation.

UNIT	Course contents	Contact Hours
Unit-I	Linear integral equations, Some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations. Resolvent kernels as a series, Laplace transform method for a difference kernel, Solution of a Volterra integral equation of the first kind.	10
Unit-II	Fredholm integral equation: Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm equations of second kind, Iterated kernels and Neumann series for Fredholm equations. Resolvent kernel as a sum of series, Fredholmresolvent kernel as a ratio of two series, Fredholm equations with separable kernels, Approximation of a kernel by a separable kernel, Fredholm Alternative, Non homogenous Fredholm equations with degenerate kernels.	10
Unit-III	Green's function, Use of method of variation of parameters to construct the Green's function for a no homogeneous linear second order boundary value problem, Basic four properties of the Green's function, Orthogonal series representation of Green's function, Alternate procedure for construction of the Green's function by using its basic four properties, Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green's function. Hilbert-Schmidt theory for symmetric kernels.	10
Unit-IV	Motivating problems of calculus of variations, Shortest distance, Minimum surface of revolution, Branchistochrone problem, Isoperimetric problem, Geodesic. Fundamental lemma of calculus of variations, Euler's equation for one dependant function and its generalization to 'n' dependant functions and to higher order derivatives, Conditional extremum under geometric	10

	constraints and under integral constraints.	

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Fully understand the properties of geometrical problems
- Be familiar with variational problems
- Be familiar isoperimetric problems
- Be thorough with different types of integral equations
- Be exposed to the decomposition method

Learning Resources	
Text Book	A. Jerri, Introduction to Integral Equations with Applications, Wiley-Blackwell; 2nd revised edition, 1999.
Reference Book and other materials	1. R. P. Kanwal, Linear Integral Equations: Theory and Technique, Birkhauser, Boston Inc; 2nd edition 2013. 2. I. M. Gelfand, and, S.V. Fomin, Calculus of Variations, Dover Publications Inc., 2000 R. Weinstock, Calculus of Variations, Dover Publications; Revised edition Edition, 2012. Wazwaz, Abdul-Majid, A first course in Integral Equations, World Scientific Publishing Company; Second edition, 2015.

SEMESTER – III

Course Code	Subject Name	L	T	P	C
MAT 0301	**Topology**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course aims to gain basic knowledge of topological spaces, types of topologies, open and closed sets .This module teaches the fundamentals of point set topology and constitute an awareness of the need for the topology in Mathematics. Students will learn about continuity, product and metric topologies and also gain knowledge about connected, compact spaces and locally connected spaces.

UNIT	Course contents	Contact Hours
Unit-I	Definition and examples of topological space, Closed sets, Closure, Dense subset, Neighborhoods, interior, exterior, boundary and accumulation points, Derived sets, Bases and sub-bases, Subspaces, product spaces and relative topology.	10
Unit-II	Continuous functions, homomorphisms, the pasting lemma, Connected and disconnected sets, connectedness on the real line, components, locally connected spaces.	10
Unit-III	Countability axioms– First and second countable spaces, Lindelof's theorems, Separable spaces, second countability and separability, Separation axioms– T_0, T_1, T_2, T_3, $T_{3½}$, T_4, their characterizations and basic properties, Urysohn's lemma and Teitze extension theorem, Statement of Urysohn'smetrization theorem	10
Unit-IV	Compactness–Continuous functions and compact sets, basic properties of compactness, compactness and finite intersection property, sequentially and countably compact sets, local compactness and one point compactification, Statements of Tychonoff's Product theorem and Stone-cechcompactification theorem.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Understand to construct topological spaces from metric spaces and using general properties of neighborhood, open sets, close sets, basis and sub-basis.
- Apply the properties of open sets, close sets, interior points, accumulation points and derived sets in deriving the proofs of various theorems.

- To understand the concepts of countable spaces and separable spaces.
- Understand the concepts and properties of the compact and connected topological spaces.

Learning Resources	
Text Book	J. R. Munkres, Topology, A First Course, PHI Pvt. Ltd., N. Delhi, Second Edition 2015
Reference Book and other materials	1.S. Willard, General Topology, Addison-Wesley, Dover Publications, 2004. 2.G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company,1st edition 3.K D Joshi, Introduction to General Topology, New Age International Publisher Second Edition,2014

Course Code	Subject Name	L	T	P	C
MAT0302	**Partial Differential Equations**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The aims of this course are familiar with the formulation and solution of PDE and to study the applications of PDE including physical problems**.** The student will learn various analytical methods and their implementation to solve real life problems.

UNIT	Course contents	Contact Hours
Unit-I	Solution of Partial Differential Equation, Transport equation-initial value problem, Non homogeneous equation, Laplace equation-fundamental solution, Mean value formulas, Properties of harmonic functions, Estimation on derivative, Harnack's inequality.	10
Unit-II	Green function, Energy methods, Boundary value problem and applications of PDE: Heat equation-fundamental solution, Mean value formula, Properties of solution, Energy methods, Wave Equation-solution by spherical means, Application of D-Alembert's principle, Energy methods.	10
Unit-III	Nonlinear first order PDE-complete integrals, Envelopes, Characteristics, Hamilton Jacobi equations, Hamilton's ODE, Hopf-Lax formula, Weak solutions, Uniqueness, Representation of solutions.	10
Unit-IV	Separation of variables, Similarity solutions (Plain & Traveling waves solutions, Similarity under scaling), Fourier transform-Plancherel's theorem, Laplace transforms, Legendere transform, Potential functions.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Understand the partial differential equation problem and analyze linear and non-linear systems.
- Solve the first-order linear and non-linear PDE's by using transform methods and other methods
- Determine the solutions of linear PDE's of second and higher order with constant coefficients
- Classify second order PDE and solve boundary value problems by using separation of variable method

Learning Resources	
Text Book	L.C. Evans, Partial Differential Equations (Graduate studies in mathematics), Orient Blackswan, 2014.
Reference Book and other materials	1. I.N. Sneddon, Elements of Partial Differential Equations, Dover Publications Inc., 2006. 2.Rao K.S., Introduction to Partial Differential Equations, Prentice Hall India Learning Private Limited; 3 edition, 2011.

Course Code	Subject Name	L	T	P	C
MAT 0303	**Operations Research**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course helps in solving problems in different environments that needs decisions. This module aims to introduce students to use quantitative methods and techniques for effective decisions–making. The course focuses to formulate and to apply the models that are used in solving business decision problems as well as in various real life problems.

UNIT	Course contents	Contact Hours
Unit-I	Operations research and its scope, Necessity of operations research in industry, Linear programming problems, Convex sets, Simplex method, Theory of simplex method, Duality theory and sensitivity analysis, Dual simplex method.	10
Unit-II	Transportation and Assignment problems of linear programming, Sequencing theory and Travelling salesperson's problem. Game theory: Two person zero-sum games, Games with mixed strategies, Graphical solutions, Solutions by linear programming	10
Unit-III	Replacement: Replacement of items that deteriorate, Problems of choosing between two machines, Replacement of items that fail completely, Problems in mortality and staffing. Inventory problems, Simple deterministic and stochastic models of inventory control.	10
Unit-IV	Network analysis: Shortest-path problem, Minimum cost flow problem, Project planning and control with PERT/CPM. Queuing theory: Steady state solution of Markovian queuing models: M/M/1, M/M/1 with limited waiting space	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Formulate some real life problems into Linear programming problems.
- Use the simplex method to find an optimal vector for the standard linear programming problem and the corresponding dual problem
- Prove the optimality condition for feasible vectors for Linear programming problem and Dual Linear programming problem.
- Find the optimal solution of transportation problem and assignment problem
- Learn the constructions of the networks of a project and optimal scheduling using CPM and PERT.
- Formulate and solution of linear programming model of two person zero sum game

- Solve nonlinear programming problems using Lagrange multiplier and using KuhnTucker conditions

Learning Resources	
Text Book	H. A. Taha, Operations Research, Pearson Education, 9th edition, 2014.
Reference Book and other materials	1. Hillier and Lieberman, Introduction to Operations Research, Mcgraw Higher Ed., 9th Edition, 2011. 2. S. D. Sharma, Operations Research Theory Methods & Applications, KedarNath Ram Nath Publishers, 2017 3. J. K. Sharma, Operations Research – Theory and Applications, Assorted Editorial, 2017. 4. S. M. Sinha, Mathematical Programming Theory and Methods, Elsevier, 2005.

SEMESTER – IV

Course Code	Subject Name	L	T	P	C
MAT 0401	**Functional Analysis**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The objective of the module is to study linear mappings defined on Banach spaces and Hilbert spaces, especially linear functional and some sequence spaces. In particular, the four big theorems in functional analysis, namely, Hahn-Banach theorem, uniform boundedness theorem, open mapping theorem and Banach-Steinhaus theorem will be covered.

UNIT	Course contents	Contact Hours
Unit-I	Normed linear spaces, Metric on normed linear spaces, Completion of anormed space, Banach spaces, subspace of a Banach space, Holder's and Minkowski's inequality, Completeness of quotient spaces of normed linear spaces. Completeness of lp, Lp, Rn, Cn and C [a, b], Incompletenormed spaces.	10
Unit-II	Finite dimensional normed linear spaces and Subspaces, Bounded lineartransformation, Equivalent formulation of continuity, Spaces of bounded linear transformations, Continuous linear functional, Conjugate spaces, Hahn-Banach extension theorem (Real and Complex form).	10
Unit-III	Riesz Representation theorem for bounded linear functionals on Lp and C [a, b], Second conjugate spaces, Reflexive space, Uniform boundedness principle and its consequences, Open mapping theorem and its application projections, Closed Graph theorem.	10
Unit-IV	Equivalent norms, Weak and Strong convergence, their equivalence in finite dimensional spaces, Weak sequential compactness, Solvability of linear equations in Banach spaces, Compact operator and its relation with continuous operator, Compactness of linear transformation on a finite dimensional space, properties of compact operators, compactness of the limit of the sequence of compact operators, the closed range theorem.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Use duality in various contexts and theoretical results from the course in concrete situations.

- Work with families of applications appearing in the course, particularly specific calculations needed in the context of Baire Category.
- Produce examples and counterexamples illustrating the mathematical concepts presented in the course.
- Understand the statements and proofs of important theorems and explain the key steps in proofs, sometimes with variation.

Learning Resources	
Text Book	H.L. Royden, Real Analysis, Pearson publishing, 4th Edition, 2015
Reference Book and other materials	1.E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, 2006. 2.George F. Simmons, Introduction to Topology and Modern Analysis,McGraw-Hill Book Company, 2004. 3.A. H. Siddiqi, Khalil Ahmad and R. Manchanda, Introduction toFunctional Analysis with Applications, Anshan Ltd; 1 edition, 2007.

Course Code	Subject Name	L	T	P	C
MAT 0402	**Research Methodology**	**3**	**1**	**0**	**3**
CORE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The primary objective of this course is to develop a research orientation among the scholars and to acquaint them with fundamentals of research methods. The course develops the understanding of the basic framework of the research process. Also gives an understanding of various research designs and techniques.

UNIT	Course contents	Contact Hours
Unit-I	Meaning of Research, Purpose, Characteristics and Types of Research, Process of Research, Formulation of objectives, Formulation of Hypotheses, Types of Hypotheses, Methods of testing Hypotheses, Research plan and its components, Methods of Research (Survey, Observation, case study, experimental, historical and comparative methods).	10
Unit-II	Scientific research and literature survey, History of mathematics, finding and solving research problems, role of a supervisor, a survey of a research topic, publishing a paper, reviewing a paper, research grant proposal writing, copyright issues, ethics and plagiarism.	10
Unit-III	Research tools: Searching google (query modifiers), MathSciNet, ZMATH, Scopus, ISI Web of Science, Impact factor, h-index, Google Scholar, ORCID, JStor, Online and open access journals, Virtual library of various countries	10
Unit-IV	Scientific writing and presentation,writing a research paper, survey article, thesis writing; LaTeX, PSTricks etc., Software for Mathematics: Mathematica/Matlab/Scilab/GAP.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Explain the epistemological assumptions of qualitative research methods, how to select the appropriate qualitative research method to address a research question, and the criteria for evaluating qualitative research methods.
- Design and conduct an in-depth interview study, an oral history interview study, a focus group study, ethnography, a qualitative content analysis study, a qualitative case study, and a mixed-method study.
- Write a qualitative methods and findings section, as for a qualitative research article.

- Design a good quantitative purpose statement and good quantitative research questions and hypotheses.
- Design a good qualitative purpose statement and a good central question in qualitative research.

Learning Resources	
Text Book	J. Stillwell, Mathematics and its History, Springer International Edition, 4th Indian Reprint, 2010.
Reference Book and other materials	1.L. Lamport, LaTeX, a Document Preparation System, 2nd Ed., Addison-Wesley, 1994. 2.Norman E. Steenrod, Paul R. Halmos, Menahem M. Schiffer, Jean A. Dieudonne, How to Write Mathematics, American Mathematical Society, 1973. 3.Nicholas J. Higham, Handbook of Writing for the Mathematical Sciences, Second Edition, SIAM, 1998. 4.Donald E. Knuth, Tracy L. Larrabee, and Paul M. Roberts, Mathematical Writing,Mathematical Association of America, Washington, D.C., 1989.

Department Elective –I

Course Code	Subject Name	L	T	P	C
MAT 0105	**Transform Techniques with Applications**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The goals for the course are to gain a facility with using the transform, both specific techniques and general principles, and learning to recognize when, why, and how it is used. Together with a great variety, the subject also has a great coherence, and the hope is students come to appreciate both.

UNIT	Course contents	Contact Hours
Unit-I	Laplace Transform: Laplace of some standard functions, Existence conditions for the Laplace Transform, Shifting theorems, Laplace transform of derivatives and integrals, Inverse Laplace transform and their properties, Convolution theorem, Initial and final value theorem, Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function, Applications of Laplace transform to solve ODEs and PDEs.	10
Unit-II	Z–transform and inverse Z-transform of elementary functions, Shifting theorems, Convolution theorem, Initial and final value theorem, Application of Z-transforms to solve difference equations.	10
Unit-III	Trigonometric Fourier series and its convergence, Fourier series of even and odd functions, Gibbs phenomenon, Fourier half-range series, Parseval`s identity, Complex form of Fourier series. Fourier integrals, Fourier sine and cosine integrals, Complex form of Fourier integral representation, Fourier transform, Fourier transform of derivatives and integrals, Fourier sine and cosine transforms and their properties, Convolution theorem, Application of Fourier transforms to Boundary Value Problems.	10
Unit-IV	Basic properties of Hankel Transform, Hankel Transform of derivatives, Application of Hankel transform to PDE. Definition and properties of Mellin transform, Shifting and scaling properties, Mellin transforms of derivatives and integrals, Applications of Mellin transform.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Students will be able to know the use of Laplace transform in system modeling, digital signal processing, process control, solving Boundary Value Problems.
- Students will be able to use Fourier transform in communication theory and signal analysis, image processing and filters, data processing and analysis, solving partial differential equations for problems on gravity.
- Students will be able to use Z-transform in the characterization of Linear Time Invariant system in development of scientific simulation algorithms.

Learning Resources	
Text Book	Phil Dyke, An Introduction to Laplace Transforms and
Reference Book and other materials	1. Fourier Series, Springer-Verlag London, 2014. 2 Robert Vich, Z Transform Theory and Applications, Springer Netherlands, 1987. 3 Urs Graf. Introduction to Hyperfunctions and Their Integral Transforms, Birkhäuser Basel, 2010.

Course Code	Subject Name	L	T	P	C
20MAT 0106	**Programmingin C++**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

This course provides fundamental knowledge of C++ Programming paradigms. Further this course focuses on basics of C++, Exception Handling and I/O, Polymorphism, Programming paradigms, object and a class, interface and implementation of a class.

UNIT	Course contents	Contact Hours
Unit-I	Programming paradigms, characteristics of object oriented programming languages, brief history of C++, structure of C++ program, differences between C and C++, basic C++ operators, Comments, working with variables, enumeration, arrays and pointer.	10
Unit-II	Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators.	10
Unit-III	Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling. Basics of C++ Exception Handling: Try Throw, Catch, Throwing an Exception;-Catching an Exception, Re-throwing an Exception, Processing Unexpected Exceptions.	
Unit-IV	Files and I/O Streams and various operations on files. Stream Input/output Classes and Objects, Stream Output, Stream Input, Unformatted I/O (with read and write).	10

LEARNING OUTCOME: Upon completing this course, students will able to:

- Acquire basic knowledge about Programming in C++
- Gather extensive knowledge in C ++ programming and developing programming skills
- Strengthen the knowledge on Files and I/O Streams of C++ programming.

Learning Resources	
Text Book	Balagurusamy, Object oriented Programming with C++, 3rd Edition, January 2006, Tata McGraw-Hill Education.
Reference Book and other materials	1.C. S. Horstmann, Computing Concepts with C++ Essentials, 3rd Edition, 2003, John Wiley & Sons Inc. 2.K. R. Venugopal and Rajkumar, Mastering C++, Tata Mcgraw Hill Education Private Limited, 2nd edition, January 2013.

Course Code	Subject Name	L	T	P	C
20MAT 0106L	**C++ Programming Lab**	**0**	**0**	**2**	**1**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE

1. Write a C++ program to implement the concept Arrays of Objects
2. Create Class 'student', create an array of students, and find out the student who get the first rank.
3. Write a C++ program to implement operator overloading to perform complex arithmetic.
4. Write a program that uses a class where the member functions are defined inside a class.
5. Write a program that uses a class where the member functions are defined outside a class.
6. Write a program to demonstrate the use of static data members.
7. Write a program to demonstrate the use of dynamic constructor.
8. Write a program to demonstrate the use of explicit constructor.
9. Write a program to demonstrate the overloading of increment and decrement operators
10. Write a program to demonstrate the overloading of binary arithmetic operators.
11. Write a program to demonstrate the overloading of memory management operators.
12. Write a program to demonstrate the typecasting of basic type to class type.
13. Write a program to demonstrate the multilevel inheritance.
14. Write a program to demonstrate the virtual derivation of a class.

Reference: Laboratory Manual

Course Code	Subject Name	L	T	P	C
MAT 0107	**Financial Mathematics**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The objectives are to provide an introduction to the basic mathematical concepts and techniques used in finance and business. This also highlights the inter-relationships of the mathematics and problem solving skills with a particular emphasis on financial and business applications.

UNIT	Course contents	Contact Hours
Unit-I	Some Basic Definitions and Terminology, Basic option theory: single and multi-period binomial pricing models, Cox-Ross-Rubinstein (CCR) model, Black Scholes formula for potion pricing as a limit of CCR model.	10
Unit-II	Brownian ad Geometric Brownian Motion, Theory of Martingales, Stochastic Calculus, Stochastic differential Equations, Ito's formula to solve SDE's, FeymannKac theorem, Application of stochastic calculus in option pricing, Black Scholes partial differential equations and Black Scholes formula.	10
Unit-III	.Mean Variance portfolio theory: Markowitz model for Portfolio optimization and Capital Asset Pricing Model (CAPM), Interest rates and interest rate derivatives:	10
Unit-IV	Binomial lattice model, Vasicek, Hull and White and Cox-IngersollRoss (CIR) Model for bond pricing.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Demonstrate understanding of basic concepts in linear algebra, relating to linear equations, matrices, and optimization.
- Demonstrate understanding of concepts relating to functions and annuities.
- Employ methods related to these concepts in a variety of financial applications.
- Apply logical thinking to problem solving in context.
- Use appropriate technology to aid problem solving.
- Demonstrate skills in writing mathematics.

Learning Resources	
Text Book	D.G. Luembergar, Investment Science, Oxford University press, 2nd edition 2013.
Reference Book and other materials	1. S.Ross, An Introduction to Mathematical Finance, Cambridge University press,3rd Edition, 2011. 2. J.C.Parikh, Stochastic Process and Financial Markets, Alpha Science International, 2003. 3. S. Roman, An Introduction the Mathematics of Finance, Springer, 1st Edition, 2000

Department Elective – II

Course Code	Subject Name	L	T	P	C
MAT 0205	**Probability & Statistics**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:
This coursedemonstrates the knowledge of probability and the standard statistical distributions. This module further extends knowledge of the properties of parametric, semi-parametric and nonparametric testing procedures. This also gives the ability to perform complex data management and the ability to apply linear, nonlinear and generalized models.
.

UNIT	Course contents	Contact Hours
Unit-I	Algebra of sets, introduction to probability,random variables, probability distributions, moments, moment generating function, Markov and Chebyshev inequalities, special discrete and continuous distributions.	10
Unit-II	Function of a random variable, joint distributions, bivariate normal distribution, transformation of random vectors, central limit theorem.	10
Unit-III	Sampling distributions, point estimation, unbiasedness, consistency, method of moments and maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems from normal populations	10
Unit-IV	Testing of hypotheses, Neyman-Pearson lemma, Tests for one sample and two sample problems for normal populations.	10

LEARNING OUTCOME:
Upon completion of this course, the student will be able to:

- Organize, present and interpret statistical data, both numerically and graphically,
- Use various methods to compute the probabilities of events,
- Analyze and interpret statistical data using appropriate probability distributions, e.g. binomial and normal,
- Apply central limit theorem to describe inferences,
- Construct and interpret confidence intervals to estimate means, standard deviations and proportions of populations,
- Perform parameter testing techniques, including single and multi-sample tests for means, standard deviations and proportions, and
- Perform a regression analysis, and compute and interpret the coefficient of correlation.

Learning Resources	
Text Book	V.K. Rohatgi and A.K. Md.E.Saleh, An Introduction to Probability and Statistics. John Willey and Sons, Third Edition 2015.
Reference Book and other materials	1. J.S. Milton & J.C.,Arnold Introduction to Probability and Statistics, Tata McGraw Hill Third Edition, 2003 2. H.J. Larson, Introduction to Probability Theory and Statistical Inference, Wiley Pub, Third Edition,1982. 3. S.M. Ross, Introduction to Probability and Statistics for Engineers and Scientists Academic Press, Fifth Edition, 2014. 4. W.W. Hines, D.C. Montgomery, D.M. Goldsman and C.M. Borror, Probability and Statistics in Engineering, John Wiley and sons, 2009.

Course Code	Subject Name	L	T	P	C
MAT 0207	Fuzzy Set Theory	3	1	0	3
DE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The purpose of this course is to introduce the concepts of fuzzy theory which includes fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic control and applications of fuzzy logic. .

UNIT	Course contents	Contact Hours
Unit-I	Fuzzy Sets: Concepts of crispness and fuzziness, crisp sets and fuzzy sets, αcuts, convex fuzzy sets, operations on fuzzy sets, type-2 fuzzy sets, fuzzy numbers and extended operations on them, LR- representations of fuzzy sets and extended operations on them, t-norm and t-conorms, increasing and decreasing generators, interval equations, fuzzy equations	10
Unit-II	Fuzzy Relations and Fuzzy Graphs: Fuzzy relations on fuzzy sets, composition of fuzzy relations, fuzzy graphs. Fuzzy Analysis: Fuzzy functions and their extrema, integration of fuzzy functions, fuzzy differentiation	10
Unit-III	Fuzzy Logic and Approximate Reasoning: Fuzzy measures and measures of fuzziness, linguistic variables, fuzzy logic, truth tables, approximate reasoning in support logic programming. Expert Systems and Fuzzy Control: Expert systems, uncertainty modeling in expert systems, fuzzy control, process of fuzzy control.	10
Unit-IV	Decision Making in Fuzzy Environments: Fuzzy decisions, fuzzy linear programming problems, fuzzy transportation problems, fuzzy dynamic programming, fuzzy multi criteria analysis	10

LEARNING OUTCOME:

`Upon completion of this course, the student will be able to:

- Draw a parallelism between crisp set operations and fuzzy set operations through the use of characteristic and membership functions respectively.
- Learn fuzzy sets using linguistic words and represent these sets by membership functions.
- Define the mapping of fuzzy sets by a function and fuzzy-set-related notions; such as α level sets, convexity, normality, support, etc.
- Know the concepts of fuzzy graph, fuzzy relation, fuzzy morphism and fuzzy numbers.
- Become familiar with the extension principle, its compatibility with the α-level sets and its usefulness in performing fuzzy number arithmetic operations.

Learning Resources	
Text Book	Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.
Reference Book and other materials	1. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 4^{th} Edition 2015. 2. John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education, 1999.

Course Code	Subject Name	L	T	P	C
MAT 0201	**Number Theory**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The aim of this course is to introduce students to some of the basic ideas of number theory, through examples, conjectures, theorems, proofs and application and to use these concepts for further context in the development of mathematics. The module will apply some basic techniques of number theory to cryptography.

UNIT	Course contents	Contact Hours
Unit-I	The Division Algorithm, the gcd, The Euclidean Algorithm, Diophantine equation ax + by = c., The fundamental theorem of arithmetic, The Sieve of Eratosthenes, The Goldbach conjecture	10
Unit-II	Theory of Congruence – Basic properties of Consequence, Linear Congruences, Chinese remainder theorem, Fermat's Theorem, Wilson's Theorem, Prime Numbers, and Statement of Prime number theorem, Some primality testing.	10
Unit-III	Number-Theoretic Functions – The functions T and Sigma, The Mobius inversion formula, The Greatest integer function, Euler's Phi function – Euler Theorem, Properties of the Phi-function, Introduction to cryptography, public key cryptography, Applications to Cryptography.	10
Unit-IV	The order of an integer modulo n, Primitive roots for primes, The theory of indices, Euler's criterion, Legendre's symbol and its properties, Quadratic reciprocity, Quadratic congruences with composite moduli, Perfect Numbers, Representation of integers as sum of two squares and sum of more than two squares.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Define and interpret the concepts of divisibility, congruence, greatest common divisor, prime, and prime-factorization,
- Apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues,
- Formulate and prove conjectures about numeric patterns, and produce rigorous arguments centered on the material of number theory, most notably in the use of Mathematical Induction and/or the Well Ordering Principal in the proof of theorems..

Learning Resources	
Text Book	Davis M. Burton: Elementary Number Theory, McGraw Hill Education, 7 edition, 2017.
Reference Book and other materials	1. I.Niven, H.S. Zuckerman and H.L.Montgomery, An Introduction to the Theory of Numbers, John Wiley & Sons (5th Ed.) 2016. 2. G. H. Hardy, E. M. Wright,An Introduction to the Theory of Numbers, Oxford University Press, 6th Ed., 2008. 3. D. M. Burton, Elementary Number Theory, McGraw Hill, 7th Ed., 2010. 4. G. E. Andrews, Number Theory, Dover Publications, 1994. 5. N. Koblitz, A Course in Number Theory and Cryptography, Springer, 2nd Ed., 2012.

Department Elective – III

Course Code	Subject Name	L	T	P	C
MAT 0304	**Fluid Dynamics**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

This course aims to understand the fluids and their characteristics. This module makes familiar with Bernoulli's equation and potential theorems,two dimensional flow in cylindrical polar coordinates and two dimensional motion, use of cylindrical polar co-ordinates to the learner
.

UNIT	Course contents	Contact Hours
Unit-I	Kinematics, Velocity at a point of a fluid, Eulerian and Lagrangianmethods,Streamlines, path lines and streak lines, Velocity potential, Irrotational and rotational motions, Vorticity and circulation, Equation of continuity, Boundary surfaces, Acceleration at a point of a fluid, Components of acceleration in cylindrical and spherical polar co-ordinates.	10
Unit-II	Pressure at a point of a moving fluid, Euler equation of motion, Equations of motion in cylindrical and spherical polar co-ordinates, Bernoulli equation, Impulsive motion, Kelvin circulation theorem, Vorticity equation, Energy equation for incompressible flow, Kinetic energy of irrotational flow, Kelvin minimum energy theorem, Kinetic energy of infinite fluid, Uniqueness theorems.	10
Unit-III	Axially symmetric flows, Liquid streaming part a fixed sphere, Motion of a sphere through a liquid at rest at infinity, Equation of motion of a sphere, Kinetic energy generated by impulsive motion, Motion of two concentric spheres, Three-dimensional sources, sinks and doublets, Images of sources, sinks and doublets in rigid impermeable infinite plane and in impermeable spherical surface.	10
Unit-IV	Two dimensional motion, Use of cylindrical polar coordinates, Stream function, Axisymmetric flow, Stoke stream function, Stoke stream function of basic flows, Irrotational motion in two-dimensions, Complex velocity potential, Milne-Thomson circle theorem, Two-dimensional sources, sinks, doublets and their images, Blasius theorem.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Understand the basic principles of fluid dynamics.
- Use Euler and Bernoulli's equations and the conservation of mass to determine velocity and acceleration for incompressible and inviscid fluid.
- Understand the concept of rotational and irrotational flow, stream functions, velocity potential, sink, source, vortex, etc.
- Analyze simple fluid flow problems (flow between parallel plates, flow through pipe, etc.) with Navier - Stoke's equation of motion.

Learning Resources	
Text Book	W. H. Besaint and A. S. Ramasey, A Treatise on Hydromechanics, Part II, CBS Publishers, Delhi, 1988.
Reference Book and other materials	1. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985. 2. O'Neill, M.E. and Chorlton, F., Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986. 3. R. K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976. 4. G.K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.

Course Code	Subject Name	L	T	P	C
MAT 0305	**Mathematical Methods**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

This course is intended to prepare the student with mathematical tools and techniques that are required in advanced courses offered in the applied mathematics and engineering programs. The module makes enable students to apply transforms and variation problem technique for solving differential equations and extremum problems.Further the learner will understand the applications of Fourier series in Sturm Lioville problems

UNIT	Course contents	Contact Hours
Unit-I	Inner products of functions, Orthogonal set of functions, Fourier series and their properties, Bessels inequality and a property of Fourier constants, Parseval's equation, Convergence of Fourier series, Fourier theorem, Uniform convergence of Fourier series.	10
Unit-II	Differentiation of Fourier series, Integration of Fourier series, Solutions of ordinary boundary value problems in Fourier series, A slab with faces at prescribed temperature, A Dirichlet problem (in Cartesian coordinates only), a string with prescribed initial velocity, an elastic bar, Applications of Fourier series in Sturm Lioville problems.	10
Unit-III	Definitions of integral equations and their classification, Relation between integral and differential equations, Fredholm integral equations of second kind with separable kernels, Reduction to a system of algebraic equations.	10
Unit-IV	Eigen values and eigen functions, iterated kernels, iterative scheme for solving Fredholm integral equation of second kind (Neumann series), Resolvent kernel, Application of iterative scheme to Volterra's integral equation of second kind.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Find solutions of linear integral equations of first and second type (Volterra and Fredhlom);
- Understand theory of calculus of variations to solve initial and boundary value problems

Learning Resources	
Text Book	J. W. Brown, R.V. Churchill, Fourier Series and Boundary Value Problems, McGraw Hill Education, New Delhi Eighth Edition, 2017
Reference Book and other materials	1. R. P. Kanwal, Linear Integral Equation, Theory and Technique, Birkhauser Pub Second Edition 2013. 2. V. Lovitt, Linear Integral Equation, Dover Publications Reissue Edition, 2005. 3. F. B. Hildebrand, Method of Applied Mathematics, CHAPTER 2 (2.1-2.11,2.19) Chapter 3 (3.1,3.2,3.6,3.11), Dover Publications New Edition 1992.

Course Code	Subject Name	L	T	P	C
MAT 0306	**Statistical Inference**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course aims to gain basic knowledge of estimation theory. Further, the course aims to arrive at an estimator that exhibits optimality and to observe data as an input and produces an estimate of the parameters. The course also includes a systematic account of Neyman Pearson theory of testing and closely related theory of point estimation and confidence sets, together with their applications.

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UNIT	Course contents	Contact Hours
Unit-I	Point and interval estimation, Unbiasedness, Efficiency, Consistency and Sufficiency, Methods of maximum likelihood and Moments for estimation	10
Unit-II	Definition of Chi-square statistic, Chi-square tests for goodness of fit and independence of attributes, Definition of Student 't' and Snedcor F-statistics, Testing for the mean and variance of univariate normal distributions, Testing of equality of two means and two variances of two univariate normal distributions, Related confidence intervals.	10
Unit-III	Neyman-Pearson lemma, liklihood ratio tests, Tests for mean and variance of a normal population, Equality of means and variances of two normal populations.	10
Unit-IV	Definition of order statistics and their distributions, Non-parametric tests, Sign test for uni- variate and bi-variate distribution, Run test, Median test and Mann Whitney-U-test.	10

LEARNING OUTCOME: Upon completion of this course, the student will be able to:

- To estimate the optimality
- To apply Neyman Pearson theory of testing and closely related theory of point estimation and confidence sets in real life applications.
- Learn order statistics and their distributions and apply Non-parametric tests according to the problem.

Learning Resources	
Text Book	A.M. Mood, F.A. Graybill and D.C. Boes, Introduction to the theory of Statistics, McGraw Hill, Third Edition 1974.
Reference Book and other materials	1. A.M. Goon, M.K. Gupta, and B. Das Gupta, Fundamentals of Statistics, Vol-II, The world press private Ltd 1975. 2. R.V. Hogg and A.T. Craig, Introduction to Mathematical Statistics, Pearson Pub Seventh Edition, 2012. 3. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, First Edition, 2014.

Department Elective – IV

Course Code	Subject Name	L	T	P	C
MAT 0307	**Mechanics**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

This course is intended to provide a treatment of basic knowledge in mechanics used in deriving a range of important results and problems related to rigid bodies. Also include the classical mechanics approach to solve a mechanical problem.

UNIT	Course contents	Contact Hours
Unit-I	Generalized coordinates, Holonomic and non-holonomic systems, Scleronomic and rheonomic systems, Constraints, Generalized potential, Lagrange's equations of motion of the second kind, Energy equation for conservative field, Derivation of Lagrange's equations from D' Alembert's principle, Simple applications of the Lagrangian formulation.	10
Unit-II	Hamilton's variables, Hamiltonian, Hamilton canonical equations, Derivation of Hamilton's equations of motion by variational principle, Simple applications of Hamilton's equations of motion, Cyclic coordinates and conservation theorems, Routh's equations of motion, The principle of least action, Derivation of Lagrange's equations from Hamilton's principle, Derivation of Hamilton's principle from D'Alembert's principle.	10
Unit-III	Fundamental lemma of calculus of variations, Some techniques of calculus of variations, Euler's equation for functions of one dependent variable and its generalization to (i) "n" dependent variables (ii) higher order derivatives, Motivating problems of calculus of variation - Shortest distance, Minimum surface of revolution, Brachistochrone problem, Isoperimetric problem, Geodesic, Conditional extremum under geometric constraints and under integral constraints.	10
Unit-IV	Canonical transformation, Poisson brackets, Equations of motion in Poisson brackets form, Poisson's theorem, Jacobi-Poisson theorem, Lagrange's brackets, Invariance of Poisson and Lagrange's brackets with respect to canonical transformations, Relation between Poisson and Lagrange's brackets.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Understand the dynamics involving a single particle like projectile motion, Simple harmonic motion, pendulum motion and related problems.
- Study the path described by the particle moving under the influence of central forces.
- Apply the concept of system of particle in finding moment inertia, directions of principle axes and consequently Euler's dynamical equations for studying rigid body motions.
- Represent the equation of motion for mechanical systems using the Lagrangian and Hamiltonian formulations of classical mechanics.
- Obtain canonical equations using different combinations of generating functions and subsequently developing Hamilton Jacobi method to solve equations of motion.

Learning Resources	
Text Book	H. Goldstein, Classical Mechanics, 2nd Edition, Narosa Publishing House, New-Delhi, 2001.
Reference Book and other materials	1. A. S. Ramsey, Dynamics Part-II, The English Language Book Society and Cambridge University Press, 1972. 2. F. Gantmacher, Lectures in Analytic Mechanics, MIR Publishers, Moscow, 1975 3. I. M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall. 4. Narayan Chandra Rana and PramodSharad Chandra Joag, Classical Mechanics, Tata McGraw Hill, 1991.

Course Code	Subject Name	L	T	P	C
MAT 0308	**Mathematical Programming**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The course aims to provide knowledge of convex sets and convex functions,Kuhn-Tucker conditions of optimality,theory of the revised simplexmethod,parametric linear programming and basic concepts in integer programming.This module covers quadratic programming with duality theory of quadratic and convex programming.

UNIT	Course contents	Contact Hours
Unit-I	Convex sets, convex functions, pseudo-convex functions, quasi-convex, explicit quasi-convex, quasi-monotonic functions and their properties from the point of view of mathematical programming. Kuhn-Tucker conditions of optimality.	10
Unit-II	Theory of revised simplex algorithm, Duality theory of linear programming, Sensitivity analysis.	10
Unit-III	Parametric linear programming, Integer programming and linear goal programming, dynamic programminng	10
Unit-IV	Quadratic programming: Wolfe's algorithm,Beale's algorithm, Theil and Vande-Panne algorithm. Duality theory of quadratic and convex programming, separable programming, sequential unconstrained minimization.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Know the notion of convex sets and functions and application of Kuhn-Tucker conditions of optimality.
- Build a mathematical programming model of a real-life situation.
- Apply a branch and bound algorithm to solve integer programming problems.
- Apply Wolfe's algorithm and Beale's algorithm for quadratic programming.
- Understand the basic theory of separable programming.

Learning Resources	
Text Book	G. Hardy, Linear Programming, Narosa Publishing house, 2002
Reference Book and other materials	1. G. Hardy, Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass, 1st Edition 1964. 2. H. A.Taha, Operations Research- An introduction, Pearson Publications 10th Edition, 2016. 3. N. S. Kambo, Mathematical Programming Techniques, Affiliated East-West Press, Revised Edition, 2008. 4. O. L. Mangasarian, Nonlinear Programming, Academic Press, 2014.

Course Code	Subject Name	L	T	P	C
20MAT 0310	**Mathematical Biology**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

This course aims to gain basic knowledge of mathematical biology, and modeling process. This module also introduces bio-fluid dynamics, blood flow, human respiratory system and diffusion.

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UNIT	Course contents	Contact Hours
Unit-I	Introduction, Definition and Scope of Bio-Mathematics, Role of Mathematics in Biosciences. Basic concepts of Fluid Dynamics, Bio-Fluid Dynamics ,Basic concepts about blood, Cardiovascular system and blood flows, Mathematical models in biology-Master equation, polymerization dynamics, Evolution-simplest model	10
Unit-II	Population dynamics. Growth and spatial spread of organisms Stochastic and deterministic models in population dynamics	`10
Unit-III	Epidemiology - the spread of plagues. Predator Prey Models- discrete and continuos, spread of disease, Diffusion processes in human system	10
Unit-IV	Mathematical study of nonlinear Volterra equations, continuous time lotka-volterracompetion model, Bifurcation theory	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Understand the role of Mathematics in Bioscience.
- Know Basic concepts about blood, and blood flows.
- Learn about epedimics and models
- Understand loktaVolterra equation and bifurcation theory

Learning Resources	
Text Book	J.N. Kapur: Mathematical Models in Biology and Medicine, Affiliated East-West Press Pvt. Ltd., New Delhi, 1985
Reference Book and other materials	1. Y.C. Fung: Bio-Mechanics, Springer-Verlag New York Inc., 1990. 2. Stanley E. Charm and George S. Kurland: Blood Flow and Microcirculation, John Wiley & Sons, 1974. 3. S.A. Levin: Frontiers in Mathematical Biology, Springer-Verlag, 1994. 4. S.K. Pundir and R. Pundir : Biomathematics, PragatiPrakashan, 2010. 5. Ching Shan Chou, AvnerFriedmanIntroduction to Mathematical Biology: Modeling, Analysis, and Simulations,springer,2017

Department Elective – V

Course Code	Subject Name	L	T	P	C
20MAT 0404	Modeling and Simulation	3	1	0	3
DE	Pre-requisite				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The objectives of the course are modeling and solving mathematical and engineering problems through the relationship between theoretical, mathematical, and computational aspects. Further, this module also makes familiar to learner with mathematical modeling of real world situations related to engineering systems development, prediction and evaluation of outcomes against design criteria.

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UNIT	Course contents	Contact Hours
Unit-I	Intoduction to mathematical modeling, Discrete Time linear models in population Dynamics, Discrete time linear Age Structured model, Discrete Time Nonlinear model in population dynamics	10
Unit-II	Introduction to Continuous Time models in population dynamics, Continous Time Single Species models	10
Unit-III	Simulation and Monte Carlo integration, Computers as inference machines, Issues in simulation Simulating from standard univariate and multivariate distributions, congruential method for uniform generators, transforming uniforms, inverse transform method, convolution method, acceptance-rejection method.	10
Unit-IV	Markov Chain Monte-Carlo simulation, Markov chains with continuous state-space, Markov chain Monte-Carlo integration, The Gibbs-sampler, Metropolis-Hastings algorithm, Random walk proposal, Hybrid strategies.	10

LEARNING OUTCOME: Upon completion of this course, the student will be able to:

- Apply Simulation and Monte Carlo integration.
- Apply different models to population dynamics
- Apply inverse transform method and convolution method.
- Know Markov Chain Monte-Carlo simulation and Metropolis-Hastings algorithm.

Learning Resources	
Text Book	G.J. McLachlan and T. Krishnan, The EM Algorithms and Extensions, Wiley, 2nd Edition 2008.
Reference Book and other materials	1. J.S. Simonoff, Smoothing Methods in Statistics, Springer, 1st Edition 2011. 2. R. Gnandesikan, Methods for Statistical Data Analysis of Multivariate Observations, Second edition, Wiley, 2011. 3. B. Riple, Stochastic simulation, Wiley Interscience, 2008. 4. J. K. Kapoor, Mathematical Modeling, New Age Publishers, 2008.

Course Code	Subject Name	L	T	P	C
MAT 0405	**Algebraic Topology**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

.The course aims to introduce the notion of homotopy, groups with pointed spaces and covering spaces which is closely associated with the fundamental groups. Moreover, to introduce the concept of free groups and presentation of a group and to compute the fundamental group of the wedge of circles.

UNIT	Course contents	Contact Hours
Unit-I	Homotopy of paths, the Fundamental group, covering spaces, the fundamental group of the circle, Retractions and fixed points, the fundamental group of the punctured plane.	10
Unit-II	Deformation retracts and hotopy type, the fundamental group of Sn, Essential and inessential maps, the fundamental theorem of Algebra.	10
Unit-III	Topology of En , Borsuk's separation theorem, deformation of subsets of E n+1, the Jordan curve theorem, fiber spaces, Hurwiczuniformization theorem.	10
Unit-IV	Classification of Surfaces: Fundamental groups of surfaces, Homology of Surfaces, Cutting and Pasting, the Classification theorem. Classification of Covering Spaces: Equivalence of Covering Spaces, Universal Covering Space, Covering Tranformations.	10

LEARNING OUTCOME: Upon completion of this course, the student will be able to:

- Grasp the basics of Algebraic Topology.
- Determine fundamental groups of some standard spaces like Euclidean spaces and spheres.
- Understand proofs of some beautiful results such as Fundamental theorem of Algebra, Hurwiczuniformization theorem, Borsuk's separation theorem.

Learning Resources	
Text Book	James R Munkres, Topology - A Modern Introduction, Prentice Hall of India,2nd Edition 2002.
Reference Book and other materials	1.James Dugundji, Topology, Allyn and Bacon, New York, 1975 2.Marwin J Greenberg & J R Harper, Algebraic Topology –A First Course, Westview Press, 1981 3.W S Massey, Algebraic Topology- An Introduction, Springer Pub 1st Edition, 1990. 4.SatyaDeo, Algebraic Topology, Hindustan Book Agency,1st Edition,

	2003. 5. E H Spanier, Algebraic Topology, Tata McGraw-Hill Private Ltd, New Delhi, 1st Edition, 1994

Course Code	Subject Name	L	T	P	C
20MAT 0406	**MATLAB**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The purpose of this is to introduce the software MATLAB for numerical computations and in particular familiarizing students with the MATLAB Desktop, basic commands through the Command window and output through the Graph window. Also introduces the module of numerical simulations.

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UNIT	Course contents	Contact Hours
Unit-I	MATLAB basics, The MATLAB environment, Basic computer programming, Variables and constants, operators and simple calculations, Formulas and functions, MATLAB toolboxes.	10
Unit-II	Matrices and vectors: Matrix and linear algebra review, Vectors and matrices in MATLAB, Matrix operations and functions in MATLAB	10
Unit-III	Computer programming: Algorithms and structures, MATLAB scripts and functions (m-files), Simple sequential algorithms - Control structures (if…then, loops).	10
Unit-IV	MATLAB programming: Reading and writing data, file handling, personalized functions, Toolbox structure, MATLAB graphic functions, Numerical methods: Solution of nonlinear equations, system of linear equations. Numerical integration. Numerical simulations	10

LEARNING OUTCOME: Upon completion of this course, the student will be able to:

- Introduce the software MATLAB for numerical computations.
- Do MATLAB programming.
- Use the MATLAB help facility, do simple (but large) calculations and print out graphs.
- Solution of nonlinear equations, Numerical integration and Numerical simulations.

Learning Resources	
Text Book	Amos Gilat, MATLAB: An Introduction with Applications, 2nd edition, Wiley, 2008.
Reference Book and other materials	1.Holly Moore, MATLAB for Engineers Pearson; 4 edition, December 2013. 2.Stormy Attaway, Matlab: A Practical Introduction to Programming and Problem Solving Butterworth-Heinemann; 3 edition,2013 3.Peter I. Kattan, Matlab for Beginners :A gentle Approach, Create space Independent Publishing Platform; Revised edition 2010

Department Elective –VI

Course Code	Subject Name	L	T	P	C
MAT 0407	**Differential Geometry**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The primary objective of this course is to understand the notion of level sets, surfaces as solutions of equations, vector fields, Weingarten equation, line integrals and parameterization of surfaces, areas, volumes, Bonnet theorem and Geodesic mappings.

UNIT	Course contents	Contact Hours
Unit-I	Theory of space curves, arc length, tangent and normal's, Curvature and torsion of curve given as the intersection of two surfaces, Involutes and Evolutes.	10
Unit-II	Metric: The first and second fundamental form, Weingarton equation, orthogonal trajectories, Mensuier theorem, Gaussian curvature, Euler's theorem, Dupin's theorem, Rodrigue's theorem, Dupin'sindicatrix.	10
Unit-III	Envelopes, Edge of regression, Ruled surface, Developable surface, Monge's theorem, Conjugate directions.	10
Unit-IV	Asymptotic lines, the fundamental equations of surface theory, Gauss's formulae, Gauss characteristic equations, MainardiCodazzi equations, Weingarton equations, Bonnet's theorem on parallel surface, Geodesics, Clairaut's theorem, Gauss Bonnet theorem, conformal mapping and Geodesic mappings, Tissot's theorem, Dini's theorem.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Compute quantities of geometric interest such as curvature and torsion.
- Introduce the method of the moving frame and over determined systems of differential equations as they arise in surface theory.
- Calculate the involute and evoluteof a curve.
- Calculate the first and the second fundamental forms of a surface.
- Calculate the Gaussian curvature, the mean curvature, the curvature lines, the asymptotic lines, the geodesics of a surface.

Learning Resources	
Text Book	J.A. Thorpe, Introduction to Differential Geometry, Springer-verlag, 1st Edition 1994.
Reference Book and other materials	1. B.O. Neill, Elementary Differential Geometry, Academic Press, 2nd Edition, 2006. 2. S. Ternberg, Lectures on Differential Geometry, Prentice-Hall, 1964. 3. M. DoCarmo, Differential Geometry of Curves and Surfaces, Dover Pub, 2nd Edition, 2016. 4. D. Laugwitz, Differential and Riemannian Geometry, Academic Press, 2014.

Course Code	Subject Name	L	T	P	C
MAT 0408	**Stochastic Processes**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

This course aims to introduce stochastic processes, Chapman-Kolmogorov equations, Stationary distribution with Applications from social, biological and physical sciences, Renewal theory and Statistical inference in MC and Markov processes.

UNIT	Course contents	Contact Hours
Unit-I	Introduction to stochastic processes (SPs): Classification of SPs according to state space and time domain, Countable state Markov chains (MC's), Chapman-Kolmogorov equations; calculation of n-step transition probability and its limit.	10
Unit-II	Stationary distribution, classification of states, transient MC, random walk and gambler's ruin problem; Applications from social, biological and physical sciences.	10
Unit-III	Discrete state space continuous time MC: Kolmogorov – Feller differential equations; Poisson process, birth and death process; Wiener process as a limit of random walk; first-passage time and other problems.	10
Unit-IV	Renewal theory: Elementary renewal theorem and applications, Statement and uses of key renewal theorem, study of residual life time process, Stationary process, weakly stationary and strongly stationary processes, Branching process, Galton-Watson branching process, probability of ultimate extinction, distribution of population size, Martingale in discrete time, inequality, convergence and smoothing properties, Statistical inference in MC and Markov processes.	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Learn about stochastic processes, their classifications and real life applications.
- Understand the concept of Markov chains and to obtain higher transition probabilities.
- Explain various properties of a Poisson process.
- Demonstrate the ideas of birth and death process, immigration-emigration process, renewal process, Regenerative stochastic process, Markov renewal process and semi Markov process. Apply the stochastic theory for modeling real systems/ phenomena and study their implications, including the reliability of the systems.

Learning Resources	
Text Book	Adke, S.R. and Manjunath, S.M, An Introduction to Finite Markov Processes, Willey, 1984.
Reference Book and other materials	1. Bharat, B.R.: Stochastic Models: Analysis and Applications, new Age International, India 2000. 2.Cinlar, E. Introduction to Stochastic Processes, Dover Publications Inc.; Reprint edition February 2013. 3. Feller, W Introduction to Probability and its Applications,Wiley publisher 3rd edition 2008 4. Harris, T.E. The Theory of Branching Processes, Springer-Verlag, 1st Edition, 2012.

Course Code	Subject Name	L	T	P	C
MAT 0409	**Computing with R**	**3**	**1**	**0**	**3**
DE	**Pre-requisite**				
	Co-requisite				
	Designed by Mathematics Department				

COURSE OBJECTIVE:

The purpose of this course is to introduce programming with the eventual aim of developing skills required to write statistical software with the examples related to numerical analysis, random number generation, matrix computations and topics related to graphics

UNIT	Course contents	Contact Hours
Unit-I	Basics of Programming, The purpose of this unit is to introduce programming with the eventual aim of developing skills required to write statistical software. Topics should include simple syntax, loops, arrays, functions, input/output, and linking to databases.	10
Unit-II	Numerical analysis and statistical applications,the purpose of this unit is to apply programming skills in methods and algorithms useful in probability, statistics and data analysis.	10
Unit-III	Topics should include numerical integration, root extraction, random number generation, Monte Carlo integration, and matrix computations.	10
Unit-IV	Topics related to graphics, descriptive statistics, representation of multivariate data, simple hypothesis tests, analysis of variance	10

LEARNING OUTCOME:

Upon completion of this course, the student will be able to:

- Write the programs for statistical software.
- Apply programming skills in methods and algorithms useful in probability, statistics and data analysis.
- Represent multivariate data and descriptive statistics.

Learning Resources	
Text Book	B.W. Kernighan and D.M. Ritchie, The C Programming Language, Second edition, Prentice Hall, 1994.
Reference Book and other materials	1.W.H. Press, S.A. Teukolsky, W.T. Vellering and B.P. Flannery, Numerical Recipes in C, Second edition, Cambridge University Press, 1993 2.B. Ryan and B.L. Joiner, MINITAB Handbook,Duxbury Pub, Fourth edition,2001. 3. R.A. Thisted, Elements of Statistical Computing, Chapman and Hall, 1st Edition 1988.