Deccan Education Society's

Fergusson College (Autonomous), Pune

Program Specific Outcomes (PSOs) and Course Outcomes (COs) 2019-20

Department of Mathematics

Programme: B.Sc. Mathematics

PSO No.	Program Specific Outcomes (PSOs) Upon completion of this programme the student will be able to
PSO1	**Academic Competence:** (i) Articulate basic concepts such as limit, continuity, and differentiability of real valued and vector valued functions of one and several variables along with the concepts of linear dependence, eigenvalues, and Eigen vectors. (ii) Apply different methods to solve the differential equations. (iii) Unify structures in Mathematics such as sets, relations and functions, logical structure, relationships among them and explore the more complex structures such as groups, rings and vector spaces.
PSO2	**Personal and Professional Competence:** (i) Apply mathematical problems and solutions in variety of contexts related to science, technology, business and industry, and illustrate these solutions using symbolic, numeric, or graphical methods. (ii) Analyse the data by selecting and using appropriate mathematical formulae or techniques in order to draw the relevant conclusion. (iii) Create proficiency in writing mathematical proofs.
PSO3	**Research Competence:** (i) Apply advanced knowledge on topics in pure mathematics, empowering the students to pursue higher education at reputed academic institutions. Impart analytic and thinking skills to develop initiatives and innovative ideas for R&D in various fields. (ii) Integrate the knowledge of Mathematics to solve problems in different branches of sciences. (iii) Create, select, adapt and apply appropriate techniques and modern computing tools for complex computing activities.
PSO4	**Entrepreneurial and Social Competence:** (i) Employ analytical skills acquired helps to get distinguishing employment opportunities in several fields including IT, Research and Development Department and Teaching field. (ii) Gain awareness about issues related to plagiarism and ethical issues related to protection of intellectual property are copyrights, trademarks and patents.

F. Y. B.Sc. Semester I		
Title of the Course and Course Code	**Calculus-I - MTS 1101**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Outline basic concepts of real numbers and define sequences and series of real numbers.	1
CO2	Interpret inequalities like Geometric Mean-Arithmetic Mean inequality, Bernoulli's inequality.	2
CO3	Apply properties of Real numbers and implement different tests for checking convergence of series.	3
CO4	Explain and apply the statements of different theorems for checking convergence and divergence of sequences and series.	4
CO5	Evaluate limit of a sequence and decide whether given sequence is convergent, divergent, bounded, monotone or Cauchy.	5
CO6	Create counter examples and support the theory with applicable examples to understand the real analysis.	6
Title of the Course and Course Code	**Algebra - MTS 1102**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall basic concepts in sets, relations and functions.	1
CO2	Interpret properties of complex numbers and polynomials.	2
CO3	Apply different principles and theorems for understanding, and solving problems on integers and complex numbers.	3
CO4	Explain the geometric concepts of algebraic properties of two complex numbers. Evaluate Division Algorithms and G.C.D. for polynomials.	4
CO5	Evaluate theory of complex numbers and problems on integers and complex numbers.	5
CO6	Create counter examples and support the theory of equivalence relation, equivalence classes, partition to illustrate that every partition gives an equivalence relation and vice-versa.	6

Title of the Course and Course Code	**Mathematics Practical-I MTS1103**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive Level**
CO1	Recall and interpret various mathematical definitions of sequences, series, real numbers, functions, relations, polynomials, complex numbers.	1
CO2	Illustrate different concepts of functions, relations, polynomials.	2
CO3	Interpret and differentiate between various types of functions. Apply equivalence relations on sets and corresponding equivalence classes.	3
CO4	Explain different methods for finding the roots of a given equation and acquire the knowledge of the relationship between coefficients and roots of an equation.	4
CO5	Determine whether the given sequence and series is convergent or not.	5
CO6	Create intuition-forming examples or counter examples and prove Conjectures in sequences and series.	6
F. Y. B.Sc. Semester II		
Title of the Course and Course Code	**Calculus II - MTS1201**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Outline and recall basic concepts of real numbers, sequences and series.	1
CO2	Interpret properties of continuous and differentiable functions.	2
CO3	Apply different principles, tests and theorems for solving problems on limit, continuity, differentiation and different aspects of real analysis.	3
CO4	Analyze and examine different principles, tests and theorems on different aspects of real analysis.	4
CO5	Evaluate nth ordered derivatives of functions.	5
CO6	Create counter examples and support the theory with applicable examples to illustrate the Fundamental Theorem of Calculus.	6

Title of the Course and Course Code	**Geometry - MTS 1202**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall basic concepts in school geometry.	1
CO2	Interpret geometrical ideas like line, plane, sphere in purely algebraic manner. Explain properties of change of axes, translation of axis, rotation of axes and rectangular Cartesian coordinates of a point in plane.	2
CO3	Apply removal of xy term and linear terms to reduce given conics to its standard form. Use the condition of tangency to get equation of Tangent plane.	3
CO4	Explain and analyze the concepts in conic sections and spheres.	4
CO5	Evaluate different concepts in lines and planes. Test whether given plane passes through the three points. Determine the length of the perpendicular from a point to a plane.	5
CO6	Create counter examples and support the theory with applicable examples to articulate different conditions in the coplanar lines.	6
Title of the Course and Course Code	**Mathematics Practical-II - MTS 1203**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall and interpret various mathematical definitions of limit, continuity, differentiation, planes, lines, spheres.	1
CO2	Illustrate different concepts of limit, continuity, differentiation,	2
CO3	Apply the properties of conics to solve problems in real life situations.	3
CO4	Differentiate between various types of limits, continuity, differentiation.	4
CO5	Evaluate limits, continuity, derivatives and nth derivatives of functions.	5
CO6	Develop different techniques to find nth derivative of product of two functions.	6

S. Y. B.Sc. Semester III		
Title of the Course and Course Code	**Calculus of Several Variables - MTS 2301**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall basic concepts related to real analysis of one variable calculus.	1
CO2	Interpret partial derivatives, chain rule, differentiability of the functions by solving numerical problems.	2
CO3	Use partial derivatives and apply Euler's theorem, Taylor's theorem and Mean value theorem for functions of two or more variables. Apply multiple integrals to find area and	3
CO4	Explain continuity, differentiability of functions of several variables and change of variables in multiple integrals.	4
CO5	Evaluate limit, partial derivatives, extreme values, multiple integrals of functions of several variables.	5
CO6	Develop idea of extreme values of real valued functions of several variables. Create counter examples and support the theory with applicable examples to understand the classical fundamental theorems in integral calculus.	6
Title of the Course and Course Code	**Ordinary Differential Equations - MTS 2302**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Define differential equations to analyze real world problems.	1
CO2	Classify the problems and recognize appropriate methods to solve differential equations by manual and technology-based methods.	2
CO3	Apply the methods of solving differential equations to real world problems.	3
CO4	Categorize differential equations and explain methods of solving them.	4
CO5	Evaluate detailed solutions of differential equations by applying differential operators and inverse differential operators.	5
CO6	Create counter examples and support the theory with applicable examples to understand the differential equations. Formulate real world problems into differential equations.	6

Title of the Course and Course Code	**Numerical Analysis - MTS 2303**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Identify the common numerical methods and use them to obtain approximate solutions.	1
CO2	Interpret the errors obtained in the numerical solution of the problems.	2
CO3	Apply numerical methods to obtain approximate solutions to mathematical problems and solve the problems of interpolation, numerical integration and ordinary differential equations.	3
CO4	Explain theory of numerical and analyse error obtained in the numerical solution of the problems.	4
CO5	Evaluate the accuracy of common numerical methods.	5
CO6	Create counter examples and support the theory with applicable examples to understand the numerical analysis.	6
Title of the Course and Course Code	**Practical Paper -1 - MTS 2304** **Based on (MTS 2303),(MTS 2301),(MTS 2302)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Describe the concepts and applications of derivatives and higher order derivatives	1
CO2	Explain and understand the ideas of derivatives and higher order derivatives Acquire the concept of finding partial derivatives and associated rules	2
CO3	Expand functions using Taylor's and Maclaurin's series, Leibnitz theorem and use their applications	3
CO4	Apply the knowledge of Lagrange multipliers in finding the extreme values of functions	4
CO5	Apply the chain rule for functions of several variables	5
CO6	Explain and apply Change variables in multiple integrals	6

S. Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Linear Algebra - (MTS 2401)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Retrieve basic concepts of real numbers, polynomials over reals and vectors and generalise the concept.	1
CO2	Interpret various mathematical properties of inner product . Articulate the concept of Eigenvalue and Eigenvectors to study various forms of Matrix Decompositions.	2
CO3	Apply the concept of orthogonality to find an orthogonal basis using Gram Schmidt process. Apply the concepts of Linear dependence and Independence, Linear transformation and corresponding matrices in solving problems.	3
CO4	Explain the concepts of Eigenvalue and Eigenvectors and study various forms of Matrix Decompositions.	4
CO5	Represent the linear transforms using matrix.	5
CO6	Create counter examples and support the theory with applicable examples to understand the linear algebra.	6
Title of the Course and Course Code	**Vector Calculus - (MTS 2402)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Retrieve basic concepts of real analysis and calculus of several variables.	1
CO2	Interpret divergence and Curl, solenoidal and irrotational vector fields.	2
CO3	Apply Green's theorem, Stokes theorem and Divergence theorem and solve the problems.	3
CO4	Explain and apply the concept of curl, gradient and divergence, total differentials.	4
CO5	Evaluate limit and continuity of vector valued functions, line integral, surface integral.	5
CO6	Create counter examples and support the theory with applicable examples to understand the vector calculus.	6

Title of the Course and Course Code	**Laplace and Fourier Transform - (MTS-2403)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Describe the Laplace transform of standard functions both from the definition and by using tables.	1
CO2	Interpret the appropriate shift theorems, properties in finding Laplace and inverse Laplace transforms.	2
CO3	Identify and apply even and odd functions to obtain its Fourier series and transforms. Apply the necessary Laplace transform techniques to solve the differential equations.	3
CO4	Explain and apply the properties of Fourier transform and use it to solve differential equations and evaluate nontrivial	4
CO5	Evaluate real form of Fourier series of standard periodic functions, nontrivial integrals.	5
CO6	Create counter examples and support the theory with applicable Laplace and Fourier transforms.	6
Title of the Course and Course Code	**Practical II - MTS 2404**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall the knowledge of a matrix, basic operations, rank and determinant of a matrix.	1
CO2	Explain the various applications of the theory of matrices to a wide variety of problems.	2
CO3	Apply the new terms Basis and Dimension and various applications of the theory of matrices to a wide variety of problems.	3
CO4	Explain the terms span, linear independence, basis, dimension, and apply these concepts to various vector	4
CO5	Evaluate kernel of linear transformations and nullity of associated vector spaces.	5
CO6	Create counter examples for the concept of linear transformations and their properties.	6

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	**Real Analysis-I - MTS3501**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Retrieve the structure of system of real numbers. Define and show the convergence of sequences and sequences, integrability of functions. State the conditions for convergence, integrability.	1
CO2	Classify sets and sequences. Compare the sets and sequences. Distinguish sets and sequences. Estimate limit of sequence, series, integral of a function. Give examples, explain, counter the statements/theorems on countability.	2
CO3	Apply, examine countability theorems, convergence tests/statements to discuss the convergence, integrability. Apply calculus to examine the integrability of functions and properties of integrable functions. Demonstrate the statements with diagrams.	3
CO4	Analyse, organise the problems to apply proper test/technique. Invent examples in support of statements and their converses, in counter to the statements.	4
CO5	Determine maps, integrals, limits Evaluate limit of sequences and sums of series, integrals. Criticize the statements by arguments and/or counter examples.	5
CO6	Produce bijective maps between equivalent sets. Create counter examples to the statements about sequences, series and integrable functions. Modify/rewrite the statements in order to make it valid.	6
Title of the Course and Course Code	**Complex Analysis-I MTS3502**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Retrieve and articulate basic concepts of complex numbers. Recall, remember and list all basic properties of complex numbers. Define calculus related properties in complex, types of elementary functions, integration and different types of series on field complex numbers.	1,2
CO2	Discuss the geometrical interpretation of algebraic properties of complex numbers.	2
CO3	Carryout and outline different maps, illustrate theorems on limit, continuity and differentiation. Illustrate different types of elementary functions on field complex numbers and integration on functions of complex numbers.	3

CO4	Classify, verify, invent different types of elementary functions, series on field complex numbers and integration on functions of complex numbers .	4
CO5	Discriminate, check and evaluate different types of complex functions on calculus related properties.	5
CO6	Create different types of complex functions on calculus related properties	6
Title of the Course and Course Code	**Group Theory** **MTS3503**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Retrieve and articulate basic concepts of algebra such as integers and functions. Recall, remember and list all basic algebraic properties of number systems. Define groups and its basic terminology, Retrieve and articulate basic concepts of complex numbers. Recall, remember and list all basic properties of complex numbers. Define calculus related properties in complex, types of elementary functions, integration and different types of series on field complex numbers.	1,2
CO2	Categorize, compare verify, examine, create different types of groups. List, carryout, outline and illustrate basic properties and theorems of groups.	1,2,3,5,6
CO3	Discriminate, check, evaluate and create different subgroups of a group.	4,5,6
CO4	Define, classify, illustrate, verify, invent homomorphism on groups and to study quotient groups and normal subgroups. List, carryout, outline and illustrate theorems on these	1,3,4,5,6
CO5	Define, classify, illustrate, verify, invent simple groups, alternating groups and to study permutation groups. List, carryout, outline and illustrate theorems on these concepts and composition of series of groups.	1,3,4,5,6
CO6	Define, classify, illustrate, verify, invent group actions and related concepts. List, carryout, outline and illustrate theorems on these concepts.	1,3,4,5,6

Title of the Course and Course Code	**Advanced Linear Algebra** **MTS3504**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall and state definitions of regarding rank of matrix, determinants, eigenvalues and eigenvectors, canonical forms. Identify proper elementary operation on matrices, eigenvectors, Jordan canonical forms.	1,4
CO2	Classify matrices, compare nature of matrices. Associate maps with matrix. Differentiate matrices, linear transformations according to rank, eigenvalues and eigenvectors, canonical forms.	2,4
CO3	Apply elementary operations to solve equations. Compute solutions of system, eigenvalues and eigenvectors, canonical forms of matrices. Interpret properties of linear	3,4
CO4	Analyse type of matrix. Classify and distinguish the matrices according to their eigenvalues, eigenvectors, determinant, and canonical forms. Identify nature of	4,1
CO5	Test the consistency of system of equations. Find rank of a matrix, evaluate solutions of system of equations, canonical form of a matrix and use it to find minimal polynomial.	5
CO6	Hypothesize the conditions for to get specific output. Produce the examples and counter examples in support to the theory. Develop the technics to get new result.	6
Title of the Course and Course Code	**Metric Spaces-I** **MTS3505**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall and and articulate basic concets of real numbers, discuss open and explain the open and closed intervals in R. Classify the intervals and sets into	1,2,3
CO2	Examine continuous functions, comact sets in R, Discriminate, check, evaluate and create different types of functions and compact sets in R.	4,5,6
CO3	Define metric spaces. Explain, solve and test different metrices on general metric space. Define different inequalities and apply them to check metrices. Examine the	1,2,3,4,5
CO4	Define sequences and their properties. Apply it to check and classify compact, connected, dense sets.	1,3,5
CO5	Define, classify, illustrate, examine, verify continuous functions on general metric space. Discriminate, check, evaluate and create different types of functions.	1,2,3,4,5,6

CO6	Recall and articulate basic concepts of real numbers, Discuss open and explain the open and closed intervals in R. Classify the intervals and sets into open and closed sets.	1,2,3
Title of the Course and Course Code	**Number Theory** **MTS3506**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall, define basic concepts of set of integers and divisibility. Discuss, illustrate theorems on divisibility. Solve and verify problems in divisibility.	1,2,3,5
CO2	Define, discuss congruence relation. Discuss, illustrate theorems on congruences. Solve and verify problems in congruences. Classify, verify, invent different types of congruence equations.	1,2,3,4,5,6
CO3	Define, illustrate, examine, verify techniques of numerical calculations	1,3,4,5
CO4	Define, illustrate, examine, verify and invent different number theoretic functions.	1,3,4,5,6
CO5	Define, illustrate, examine, verify and invent different congruences laws and , Legendre's symbol.	1,2,3,4,5,6
CO6	Recall, define basic concepts of set of integers and divisibility. Discuss, illustrate theorems on divisibility.	1,2,3,5
Title of the Course and Course Code	**Operations research** **MTS3507 (SEC-1)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall and articulate basic concepts of LPP. Formulate LPP, Calculate and illustrate graphical solution. Discuss, execute, explain, illustrate, use simplex method.	1,2,3,6
CO2	Construct and solve LPP in equation form, translate, formulate graphical to algebraic solution.	1,2,3,4,6
CO3	Define, explain, solve dual LPP. Relate, compare primal and dual LPP.	1,2,3,4
CO4	Define, explain, solve transportation model. Use, execute various methods to solve transportation model. Test, verify optimal solution.	1,2,3,4,5
CO5	Define, explain, solve assignment problem. Use, execute various methods to solve assignment problem. Test, verify optimal solution.	1,2,3,4,5
CO6	Recall and articulate basic concepts of LPP. Formulate LPP, Calculate and illustrate graphical solution. Discuss, execute, explain, illustrate, use simplex method.	1,2,3,6

Title of the Course and Course Code	**Financial Mathematics-I** **MTS3508 (SEC-2)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall and articulate basic concepts of simple Interest, , Calculate and illustrate interest with discrete and continuous compounding . Discuss, execute, explain, illustrate, use time value of money.	1,2,3,6
CO2	Construct deterministic cash flows, translate, formulate Internal rate of return, NPV.	1,2,3,4,6
CO3	Define, explain random cash flows.	1,2,3,4
CO4	Define, explain, solve Markowitz model. Use, execute various methods to solve it.	1,2,3,4,5
CO5	Define, explain, solve CAPM, Use of Portfolio diagrams	1,2,3,4,5
CO6	Formulate CAPM, Calculate and illustrate CAPM formula and Discuss, execute, explain, illustrate, use it.	1,2,3,6
Title of the Course and Course Code	**Python Programming** **MTS3509 (SEC-3)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Describe various constructs of python programming.	1
CO2	Write, compile, run, and test python programs.	3,5,6
CO3	Illustrate file handling operations in Python.	2,3
CO4	Write interactive applications using Database, GUI and multithreading.	6
CO5	Explain different programming concepts in python.	2,4
CO6	Test and validate Python applications	5
Title of the Course and Course Code	**Partial Differential Equations** **MTS3510 (SEC-4)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall cartesian and parametric equations of curves and surfaces in the space. Remember the methods of solving partial differential equations.	1
CO2	Categorize the types of differential equations. Clarify, discuss, the existence of solutions and estimate solutions of differential equations.	2,3,4

CO3	Apply method to solve the partial differential equations. Demonstrate the method of solving the differential equations. Modify the initial conditions in order to solve the	3
CO4	Analyse the differential equation in order to apply proper method of solution. Compare, explain differential equations in order to study stability, solvability, method of solutions.	2,4
CO5	Evaluate, compare general solution, complete solution, particular solution, singular solutions of first order and second order partial differential equations.	4,5
CO6	Create counter examples for which method of solution fails. Assemble, develop, modify various techniques to solve the differential equation completely.	3,6
Title of the Course and Course Code	**Combinatorics** **MTS3511 (SEC-5)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall and articulate basic concepts of counting principles, Calculate and illustrate formulae for Permutation of combinations. Discuss, execute, explain, illustrate, use of Pigeonhole principle.	1,2,3,6.
CO2	Construct and formulate Recurrence relations.	1,2,3,4,6.
CO3	Define, explain, apply Inclusion-Exclusion Principle.	1,2,3,4.
CO4	Explain, solve Use, execute various counting principles and Binomial Identities	1,2,3,4,5.
CO5	Define, explain, solve distribution problems.	1,2,3,4,5.
CO6	Formulate CAPM, Calculate and illustrate Binomial identities and Multinomial theorem and Discuss, execute, explain, illustrate, use it.	1,2,3,6.
Title of the Course and Course Code	**Practical –I based on MTS3501 & MTS3502** **MTS3512**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Retrieve the structure of system of real and complex numbers. Discuss the convergence of sequences and sequences, integrability of functions. State the conditions for convergence, integrability. Using free software	1,2
CO2	Classify sets and sequences. Compare the sets and sequences. Distinguish sets and sequences. Estimate limit of sequence, series, continuity , differentiability and integral of a real and complex valued functions. Give examples, explain, counter the statements/theorems on countability. Using free software whenever possible.	2,3,4,5,6

CO3	Apply, examine countability theorems, convergence tests/statements to discuss the convergence, integrability. Apply calculus to examine the integrability of functions and properties of integrable functions.(real/complex) Using free software whenever possible	2,3
CO4	Demonstrate the statements with diagrams. Analyse, organise the problems to apply proper test/technique. Invent examples in support of statements and their converses, in counter to the statements. .(real/complex) Using free software whenever possible.	3,4,5
CO5	Determine maps, integrals, limits Evaluate limit of sequences and sums of series, integrals. Criticize the statements by arguments and/or counter examples. (real/complex). Using free software whenever possible.	4,5
CO6	Produce bijective maps between equivalent sets. Create counter examples to the statements about sequences, series and integrable (real/complex) functions. Modify/rewrite the statements in order to make it valid. Using free software whenever possible.	1,2, 4, 5.6
Title of the Course and Course Code	**Practical –II based on MTS3503 & MTS3504** **MTS3513**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Articulate and retrieve basic concepts such as integers, functions, rank of a matrix, eigenvalues, eigenvectors, determinants manually and using free software whenever	1,2,4
CO2	Categorize, compare verify, examine, create different types of groups. List, carryout, outline and illustrate basic properties and theorems of groups and matrices manually and using free software whenever possible.	2,3,4,5,6
CO3	Discriminate, check, evaluate and create different subgroups of a group and group homomorphisms manually and using free software whenever possible.	1,3,4,5,6
CO4	Apply elementary operations to solve equations. Compute solutions of system, eigenvalues and eigenvectors, canonical forms of matrices. Interpret properties of linear transformation manually and using free software whenever	3,4
CO5	Test the consistency of system of equations. Find rank of a matrix, evaluate solutions of system of equations, canonical form of a matrix and use it to find minimal polynomial manually and using free software whenever possible.	5
CO6	Define, classify, illustrate, verify, invent group actions and related concepts. List, carryout, outline and illustrate theorems on these concepts manually and using free software whenever possible.	1,3,4,5,6

Title of the Course and Course Code	**Practical –III based on Paper SEC** **MTS3514**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Articulate and retrieve basic concepts encountered in the course opted by student manually and using free software whenever possible.	1,2,4
CO2	Categorize, compare verify, examine, create different concepts encountered in the course opted by student using free software whenever possible.	2,3,4,5,6
CO3	Discriminate, check, evaluate and create different concepts encountered in the course opted by student manually and using free software whenever possible.	1,3,4,5,6
CO4	Apply elementary concepts and compute solutions of various concepts encountered in the course opted by student manually and using free software whenever possible.	3,4
CO5	Test and evaluate solutions of concepts encountered in the course opted by student manually and using free software whenever possible.	5
CO6	Classify, illustrate, verify, invent concepts encountered in the course opted by student manually and using free software whenever possible.	1,3,4,5,6
T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	**Real Analysis-II** **MTS3601**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall the convergence of sequences and series of functions, Riemann integrability of functions. Identify, state, show limits, tests, conditions for convergence.	1,4
CO2	Clarify. Compare, estimate sequences and series of functions, properties/identities about elementary functions, convergence/divergence of improper integrals, applicability of DUIS.	2,3,4
CO3	Apply tests of convergence, properties of elementary functions to prove identities, DUIS to prove results. Generalize the statements for large class of functions/sequences of functions, integrals.	2,3
CO4	Analyse the sequence and series, properties of elementary functions to prove the identities. Compare, detect, identify function to test the convergence.	1,2,4

CO5	Evaluate limit of sequence/series, combinations of elementary functions, improper integrals and write the conclusion. Criticise the properties of functions analytically and geometrically.	5,6
CO6	Produce counter examples for false statements, non-validity of converse of the statement. Combine statements and predict the result. Design the statement from examples.	5,6
Title of the Course and Course Code	**Complex Analysis-II** **MTS3602**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Articulate and retrieve basic concepts of first semester complex analysis.	1,2
CO2	Define residues and poles and its basic terminology. Categorize, compare verify, examine, create different types of residues and poles.	1,2,3,5,6
CO3	List, carryout, outline and illustrate basic properties and theorems of residues and poles.	4,5,6
CO4	Apply residues and poles to evaluate improper integrals. List, carryout, outline and illustrate theorems on complex integration.	1,3,4,5,6
CO5	Define, classify, illustrate, verify, invent mappings by elementary functions. List, carryout, outline and illustrate theorems on these concepts.	1,3,4,5,6
CO6	Define, classify, illustrate, verify, invent conformal mappings. List, carryout, outline and illustrate theorems on these concepts.	1,3,4,5,6
Title of the Course and Course Code	**Ring Theory** **MTS3603**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Articulate and retrieve basic concepts of integers, polynomials, matrices, functions and group theory.	1,2
CO2	Define ring and its basic terminology. Categorize, compare verify, examine, create different examples of rings.	1,2,3,5,6
CO3	List, carryout, outline and illustrate basic properties and theorems of rings.	4,5,6
CO4	Define, classify, illustrate, verify, invent ideals, subrings of a ring. List, carryout, outline and illustrate theorems on these concepts.	1,3,4,5,6

CO5	Define, classify, illustrate, verify, invent different types of domains. List, carryout, outline and illustrate theorems on these concepts.	1,3,4,5,6
CO6	Define, classify, illustrate, verify, invent polynomial rings and so learn concepts of irreducible polynomials. List, carryout, outline and illustrate theorems on these concepts.	1,3,4,5,6
Title of the Course and Course Code	**Dynamical Systems** **MTS3604**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall differentiable functions, eigenvalues and eigenvectors of matrix, canonical forms of matrices, phase portraits.	1,2
CO2	Classify the linear systems form eigenvalues and eigenvectors of coefficient matrices, discuss the nature of system geometrically. Draw the phase portrait diagrams of continuous and discrete dynamical systems.	2,4,5,6
CO3	Calculate eigenvalues and eigenvectors of coefficient matrix of linear systems and classify the systems. Apply basic calculus to understand solutions of differential equations. Examine the nature of the solutions.	2,3,4
CO4	Analyse the nature of solution by the differential equations, systems with conjugate linear systems. Discriminate the systems according to the stability, type of critical points, type of bifurcations.	4,1
CO5	Evaluate, determine the Poincare map for a first order equation, critical points, eigenvalues and eigenvectors for linear systems, exponential of a matrix, variational equation for nonlinear systems, critical point of a systems.	4,5
CO6	Produce, create examples of systems for the given phase portrait, conjugate to the given system. Formulate the system for simple problems.	6
Title of the Course and Course Code	**Metric Spaces-II** **MTS3605**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall and articulate basic concepts of metric spaces, Discuss continuous functions and their properties. Classify connected subsets of R.	1,2,3
CO2	Examine connected spaces. Discriminate, check, evaluate and create different types connected spaces, sets.	4,5,6
CO3	Define compact metric spaces. Explain, solve and test different compact metric space.	1,2,3,4

CO4	Discuss continuous functions on compact metric spaces. Classify, illustrate, verify, invent different compact metric spaces.	2,3,5,6
CO5	Define complete metric space. Discuss, classify, verify, invent and create different complete metric spaces.	1,2,3,4,5,6
CO6	Recall and articulate basic concepts of metric spaces, Discuss continuous functions and their properties. Classify connected subsets of R.	1,2,3
Title of the Course and Course Code	**Differential Geometry** **MTS3606**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall and articulate basic concepts such as Parametric and Cartesian curves, surfaces. Discuss their properties. Classify curves as planar curves and space curves using	1,2,3
CO2	Examine plane curves. Evaluate their signed curvature and classify the curves	4,5,6
CO3	Define the first fundamental form and evaluate them. Define normal on a surface and regular surfaces.	1,2,3,4
CO4	Discuss diffeomorphisms between surfaces. Classify, illustrate, verify, invent different diffeomorphisms as conformal maps ,isometry and equiareal maps.	2,3,5,6
CO5	Define and evaluate surface area. Discuss the relation between the area and the first fundamental form. Create different equiareal diffeomorphisms.	1,2,3,4,5,6
CO6	Define the second fundamental form and evaluate them for different surface patches of the same surface.	1,2,3
Title of the Course and Course Code	**Optimization Techniques** **MTS3607 (SEC-6)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Define, explain activities, CPM and PERT. Construct, create, design, verify, execute, test critical path, time schedule. Formulate LPP of CPM and PERT	1,2,3,4,5,6
CO2	Define, explain, classify, execute, compare different decision criterion. Define, explain, solve game. Discuss properties of game, formulate LPP model.	1,2,3,4,6
CO3	Define, discuss, explain, execute types of failure. Define, explain, classify, execute, replacement policy of items.	1,2,3,4
CO4	Define, discuss, explain, execute sequencing problem of job. Construct, create, verify optimal sequence.	1,2,3,4,5,6
CO5	Define, discuss, explain, and execute unconstrained	1,2,3,4

CO6	Discuss, use, solve and construct optimal solution using various methods.	2,3,6
Title of the Course and Course Code	**Financial Mathematics-II** **MTS3608 (SEC-7)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall and articulate basic concepts of forwards and futures Calculate and illustrate the value of a future contract discrete and continuous compounding Discuss, execute, explain, illustrate, use of replicating portfolios	1,2,3,6
CO2	Construct hedging, translate, formulate currency future and stock index futures	1,2,3,4,6
CO3	Define, explain call and put options and their types, Evaluate them.	1,2,3,4
CO4	Define and explain put-call parity and solve various problems model. Use, execute and explain various factors which affect the stock options	1,2,3,4,5
CO5	Define, explain, Black Scholes model and use of the formula. Define, Explain and use Greeks.	1,2,3,4,5
CO6	Formulate BOPM, Calculate and illustrate BOPM formula and Discuss, execute, explain, illustrate, use it.	1,2,3,6
Title of the Course and Course Code	**Graph Theory** **MTS3609 (SEC-8)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Articulate and retrieve basic concepts of induction, logic and methods of proofs.	1,2
CO2	Define graph and its basic terminology. Categorize, compare verify, examine, create different examples of graphs.	1,2,3,5,6
CO3	Define, classify, illustrate, verify, invent paths and cycles. List, carryout, outline and illustrate theorems on these concepts.	4,5,6
CO4	Define, classify, illustrate, verify, invent trees. List, carryout, outline and illustrate theorems on these concepts.	1,3,4,5,6
CO5	Define, classify, illustrate, verify, invent planar graphs.	1,3,4,
CO6	List, carryout, outline and illustrate theorems on planarity.	4,5,6

Title of the Course and Course Code	**Lebesgue Integration** **MTS3610 (SEC-9)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall, identify sets of measure zero, Riemann integrable functions, open sets, closed sets, sequences of functions, inner product, norm linear space, integrable functions, even, odd functions, periodic functions.	1
CO2	Categorize, compare the Riemann integrable functions and Lebesgue integrable functions, measurable functions, integrable functions. Illustrate, compute statements with a particular example.	2,4,6
CO3	Apply properties of measurable sets, functions. Examine a sets, functions for measurability, integrability. Apply dominated convergence theorem, Fatou's lemma.	2
CO4	Classify sets, functions according to measurability, integrability. Compare sets, functions according to their measure, integrals, Explain applicability of theorems in a	2, 4
CO5	Evaluate, determine measure of a set, integral of a function, Fourier series. Compare, criticize functions and their integrals on different sets.	4,5
CO6	Create example of non-measurable function. Generate counter examples for the theorems. Hypothesize the conditions for integrability, convergence of Fourier series.	6
Title of the Course and Course Code	**Mathematical Models in Population Biology** **MTS3611 (SEC-10)**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Recall, identify sets of measure zero, Riemann integrable functions, open sets, closed sets, sequences of functions, inner product, norm linear space, integrable functions, even, odd functions, periodic functions.	1,3,6
CO2	Categorize, compare the Riemann integrable functions and Lebesgue integrable functions, measurable functions, integrable functions. Illustrate, compute statements with a particular example.	2,4,5
CO3	Apply properties of measurable sets, functions. Examine a sets, functions for measurability, integrability. Apply dominated convergence theorem, Fatou's lemma.	3,4
CO4	Classify sets, functions according to measurability, integrability. Compare sets, functions according to their measure, integrals, Explain applicability of theorems in a	4,1

CO5	Evaluate, detrrmine measure of a set, integral of a function, Fourier series. Compare, critisize functions and their integrals on different sets.	5
CO6	Create example of non-measurable function. Generate counter examples for the theorems. Hypothesize the conditions for integrability, convergence of Fourier series.	6
Title of the Course and Course Code	**Practical –IV based on MTS3501 & MTS3502** **MTS3612**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Retrieve the structure of series of real and complex valued functions. Discuss the convergence of sequences and sequences of real valued functions. State the conditions for convergence, integrability. Using free software whenever	1,2
CO2	Classify residues and poles.. Compare the sets and sequences. Distinguish sets and sequences. Estimate limit of sequence, series, continuity , differentiability and integral of a real and complex valued functions. Give examples, explain, counter the statements/theorems on countability. Using free software whenever possible.	2,3,4,5,6
CO3	Apply residues and poles to evaluate improper integrals. List, carryout, outline and illustrate theorems on complex integration.	1,3,4,5,6
CO4	Demonstrate the statements with diagrams. Analyse, organise the problems to apply proper test/technique. Invent examples in support of statements and their converses, in counter to the statements. .(real/complex) Using free software whenever possible.	3,4,5
CO5	Determine maps, integrals, limits Evaluate limit of sequences and sums of series, integrals. Criticize the statements by arguments and/or counter examples. (real/complex). Using free software whenever possible.	4,5
CO6	Produce bijective maps between equivalent sets. Create counter examples to the statements about sequences, series and integrable (real/complex) functions. Modify/rewrite the statements in order to make it valid. Using free software whenever possible.	1,2, 4, 5.6

Title of the Course and Course Code	**Practical –V based on MTS3603 & MTS3604** **MTS3613**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Classify the linear systems form eigenvalues and eigenvectors of coefficient matrices, discuss the nature of system geometrically. Draw the phase portrait diagrams of continuous and discrete dynamical systems.	2,4,5,6
CO2	Classify the linear systems form eigenvalues and eigenvectors of coefficient matrices, discuss the nature of system geometrically. Draw the phase portrait diagrams of continuous and discrete dynamical systems. Calculate eigenvalues and eigenvectors of coefficient matrix of linear systems and classify the systems. Apply basic calculus to understand solutions of differential equations. Examine the nature of the solutions.	1,2,3,4,6
CO3	List, carryout, outline and illustrate basic properties and theorems of rings and integral domains	1,3, 4,5,6
CO4	Define, classify, illustrate, verify, invent ideals, subrings of a ring. List, carryout, outline and illustrate theorems on these concepts.	1,3,4,5,6
CO5	Evaluate, determine the Poincare map for a first order equation, critical points, eigenvalues and eigenvectors for linear systems, exponential of a matrix, variational equation for nonlinear systems, critical point of a systems.	4,5
CO6	Define, classify, illustrate, verify, invent polynomial rings and so learn concepts of irreducible polynomials. List, carryout, outline and illustrate theorems on these concepts.	1,3,4,5,6

Title of the Course and Course Code	**Practical –VI based on Paper SEC** **MTS3614**	**Number of Credits: 02**
On completion of the course, the students will be able to:		**Bloom's Cognitive level**
CO1	Articulate and retrieve basic concepts encountered in the course opted by student manually and using free software whenever possible.	1,2,4
CO2	Categorize, compare verify, examine, create different concepts encountered in the course opted by student using free software whenever possible.	2,3,4,5,6
CO3	Discriminate, check, evaluate and create different concepts encountered in the course opted by student manually and using free software whenever possible.	1,3,4,5,6
CO4	Apply elementary concepts and compute solutions of various concepts encountered in the course opted by student manually and using free software whenever possible.	3,4
CO5	Test and evaluate solutions of concepts encountered in the course opted by student manually and using free software whenever possible.	5
CO6	Classify, illustrate, verify, invent concepts encountered in the course opted by student manually and using free software whenever possible.	1,3,4,5,6