Deccan Education Society's
FERGUSSON COLLEGE (AUTONOMOUS), PUNE

Syllabus

for

S.Y.B.Sc. (Mathematics)

[Pattern 2019]

(B.Sc. Semester-III and Semester-IV)

From Academic Year

2020-21

Deccan Education Society's
Fergusson College (Autonomous), Pune

S.Y.B.Sc. Mathematics(Pattern 2019)

From academic year 2020-21

Particulars	Name of Paper	Paper Code	Title of Paper	No. of Credits
S.Y. B.Sc. Semester III	Theory Paper - 1	MTS 2301	Calculus of Several Variables	2
	Theory Paper – 2(A)	MTS 2302	Ordinary Differential Equations	2
	Theory Paper – 2(B)	MTS 2303	Numerical Analysis	2
	Practical Paper - 1	MTS 2304	Practical-III (based on Paper I and II)	2
S.Y. B.Sc. Semester IV	Theory Paper - 3	MTS 2401	Linear Algebra	2
	Theory Paper – 4A	MTS 2402	Vector Calculus	2
	Theory Paper – 4B	MTS 2403	Laplace and Fourier Transforms	2
	Practical Paper - 2	MTS 2404	Practical-IV (based on Paper I and II)	2

S.Y. B.Sc. Semester III		
Title of the Course and Course Code	**Calculus of Several Variables** **(MTS 2301)**	**Number of Credits : 02**

Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Recall basic concepts related to real analysis of one variable calculus.
CO2	Interpret partial derivatives, chain rule, differentiability of the functions by solving numerical problems.
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 volume.
CO4	Explain continuity, differentiability of functions of several variables and change of variables in multiple integrals.
CO5	Evaluate limit, partial derivatives, extreme values, multiple integrals of functions of several variables.
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.

Unit No.	Title of Unit and Contents	No of Lectures
I	**Limits, Continuity and Differentiability:** Functions of two and three variables, Notions of limits and continuity, Limit along a path, Examples. Definition and examples of Partial Derivatives, Differential and differentiability, necessary and sufficient conditions for differentiability, Higher order partial derivatives, Schwartz's theorem without proof, Young's theorem without proof	**12**
II	**Chain Rules and Extreme Values**: Chain Rules of f(g(x,y)) and f(g(u,v),h(u,v)), Euler's theorem for homogeneous functions.Mean Value theorem, Taylor's theorem for functions of two variables, Extreme values of functions of two variables.Necessary conditions for extreme values.Sufficient conditions for extreme values. Lagrange's method of undetermined coefficients.	**12**
III	**Multiple Integrals**: Double integrals, evaluation of double integrals. Change of order of integration for two variables.Double integration in Polar co-ordinates.Triple integrals.Evaluation of triple integrals.Jacobians, Change of variables (Results without proofs) Applications to Area and Volumes.	**12**

Learning resources: V. V. Acharya and M. R. Modak, Calculus of Several Variables, pdf book.

References:

1. T.M. Apostol, Calculus Vol. II (IInd Edition), John Willey, New York, (1967)
2. Shanti Narayan and P.K. Mittal, A Course of Mathematical Analysis, S. Chand and Co. 12th Edition, 1979.
3. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein (2009). *Basic Multivariable Calculus*, Springer India Pvt. Limited
4. John M. H. Olmsted, Advanced Calculus, Eurasia Publishing House, New Delhi,1970.
5. D.V. Widder, Advanced Calculus (IInd Edition), Prentice Hall of India, New Delhi, 1944.
6. M.R. Spiegel, Advanced Calculus: Schaum Series
7. James Stewart (2012). *Multivariable Calculus* (7th edition). Brooks/Cole. Cengage.
8. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011). *Calculus* (3rd edition), Pearson Education. Dorling Kindersley (India) Pvt. Ltd.
9. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018). *Thomas*' *Calculus* (14th edition). Pearson Education.

S.Y. B.Sc. Semester III		
Title of the Course and Course Code	**Ordinary Differential Equations (MTS 2302)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define differential equations to analyze real world problems.	
CO2	Classify the problems and recognize appropriate methods to solve differential equations by manual and technology-based methods.	
CO3	Apply the methods of solving differential equations to real world problems.	
CO4	Categorize differential equations and explain methods of solving them.	
CO5	Evaluate detailed solutions of differential equations by applying differential operators and inverse differential operators.	
CO6	Create counter examples and support the theory with applicable examples to understand the differential equations. Formulate real world problems into differential equations.	

Unit No.	Title of Unit and Contents	No of Lectures
I	**Differential Equations of first order and first degree:** 1. Differential Equations of first order and first degree: 2. Formation of differential equations 3. Solution of differential equation, Existence and uniqueness, Picard's Theorem (statement only), Sketching the solutions 4. Variables separable form and Homogeneous Differential Equations 5. Exact Differential Equations. Examples of Non-Homogeneous equations. 6. Condition for exactness. (Necessary and sufficient condition) 7. Integrating factor, Rules of finding integrating factors. 8. Linear Differential Equations, Bernoulli's equation. 9. Differential equation of first order but not of degree one.	**14**
II	**Linear Differential Equations with constant coefficients:** 1. Existence and uniqueness Theorem (statement), General solution, Particular solution 2. General Solution of homogeneous equation: Linear dependence-independence of solutions, Wronskian. 3. Use of known solution to find another. 4. Solution of Homogeneous Equation with constant Coefficients 5. Solution of Non-homogeneous equations: (a) Method of undetermined coefficients (b) Method of variation of parameter (c) Method of reduction of order	**14**
III	**Higher Order Differential Equations:**	**8**

	1. Successive integrations, 2. Partial fractions decompositions, 3. Series expansions of operators, 4. The exponential shift rule.	

Learning resources:

1. George F. Simmons, Differential Equations with Applications and Historical Notes.
2. V. V. Acharya and M. R. Modak, Differential equations, pdf book.

References:

1. Rainville and Bedient, Elementary Differential Equations, Macmillan Publication.
2. Daniel Murray, Introductory Course in Differential Equations, Orient Longman
3. G.F. Simmons and S. Krantz, Differential Equations with Applications and Historical notes, Tata Mc-Graw Hill.

S.Y. B.Sc. Semester III		
Title of the Course and Course Code	**Numerical Analysis (MTS 2303)**	**Number of Credits : 02**

Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Identify the common numerical methods and use them to obtain approximate solutions.
CO2	Interpret the errors obtained in the numerical solution of the problems.
CO3	Apply numerical methods to obtain approximate solutions to mathematical problems and solve the problems of interpolation, numerical integration and ordinary differential equations.
CO4	Explain theory of numerical and analyse error obtained in the numerical solution of the problems.
CO5	Evaluate the accuracy of common numerical methods.
CO6	Create counter examples and support the theory with applicable examples to understand the numerical analysis.

Unit No.	Title of Unit and Contents	No of Lectures
I	**a. Errors:** (1) Rounding off numbers to n significant digits, to n decimal places. (2) Absolute, relative and percentage errors. **b. Solution of Equations:** (1) Location of roots. (2) Descartes' Rules. (3) Sturm's theorem (without proof). (4) Regula Falsi theorem. (5) Newton- Raphson Method.	**12**

II	**a. Fitting of Polynomials:** (1) Least Square Method. (2) Fitting of (i) Straight Line. (ii) Second Degree Curve. (iii) Power Function ax^b (iv) Exponential Function ae^{bx} **b. Interpolation:** (1) Operators Δ, ∇, E and their relations. (2) Fundamental theorem of difference calculus. (3) Newton's Interpolation Formulae (Forward and Backward with proofs). (4) Lagrange's Interpolation Formula with proof. (5) Divided difference formula and Newton's divided difference formula.	**12**
III	**a. Numerical Integration:** (1) General quadrature formula. (2) Trapezoidal rule (3) Simpsons's $\frac{1}{3}^{rd}$ rule. (4) Simpsons's $\frac{3}{8}^{th}$ rule. **b. Numerical solution of first order ordinary differential equations:** a. Euler's method. b. Modified Euler's methods. c. Runge - Kutta Methods 1^{st} and 2^{nd} order.	**12**

Learning resources:

1. K.E. Atkinson, An Introduction to Numerical Analysis, Wiley Publications.
2. S.S. Sastry, Introduction to Nemerical Analysis, 3^{rd} edition, Prentice Hall

References:

1. Brian Bradie (2006), A Friendly Introduction to Numerical Analysis. Pearson.
2. C. F. Gerald & P. O. Wheatley (2008). Applied Numerical Analysis (7_{th} edition),Pearson Education, India.
3. F. B. Hildebrand (2013). Introduction to Numerical Analysis: (2_{nd} edition). Dover Publications.
4. M. K. Jain, S. R. K. Iyengar & R. K. Jain (2012). Numerical Methods for Scientific and Engineering Computation (6_{th} edition). New Age International Publisher
5. Robert J. Schilling & Sandra L. Harris (1999). Applied Numerical Methods for Engineers Using MATLAB and C. Thomson-Brooks/Cole.

S.Y. B.Sc. Semester III		
Title of the Course and Course Code	**Practical Paper -1** **MTS 2304** **Based on (MTS 2303),(MTS 2301),(MTS 2302)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the concepts and applications of derivatives and higher order derivatives	
CO2	Explain and understand the ideas of derivatives and higher order derivatives Acquire the concept of finding partial derivatives and associated rules	
CO3	Expand functions using Taylor's and Maclaurin's series, Leibnitz theorem and use their applications	
CO4	Apply the knowledge of Lagrange multipliers in finding the extreme values of functions	
CO5	Apply the chain rule for functions of several variables	
CO6	Explain and apply Change variables in multiple integrals	

List of practicals (Compulsory 10 + 2 Activity)

List of Practicals based on **MTS 2301: Calculus of Several Variables:**

1. Limits and continuity of real valued functions
2. Partial derivatives
3. Extreme values
4. Lagrange's method
5. Multiple Integrals
6. Applications of Integration

List of Practicals based on **MTS 2302: Ordinary Differential Equations:**

1. Formation of differential equations: Real world problems, Numerical Problems,

2. Solutions of differential equations: Sketching the solutions using simple calculus, using softwares such as winplot, Maxima etc.
3. Growth, Decay, Chemical reactions, Mixing, Falling bodies
4. Homogeneous equation, Exact equation, Integrating Factors
5. Orthogonal Trajectories, Hanging Chain, Pursuit curves, Simple Electrical Circuit
6. Second order equations: Wronskian, Solution of homogeneous and nonhomogeneous equations
7. Differential operators and inverse differential operators
8. Vibrations of Electrical and Mechanical Systems
9. Newton's laws of gravitation and motion of planets
10. System of first order ordinary differential equations
11. Series solution of differential equations

List of Practicals based on **MTS 2303: Numerical Analysis:**

1. Errors and solutions of equations
2. Fitting of Polynomials
3. Interpolation
4. Numerical Integration
5. Numerical solution of first order ordinary differential equations:
6. Miscellaneous

Additional Readings/Projects:

1) The Brachistochrone Problem
2) Some ideas from the theory of probability: The normal distribution curve and its differential equations.
3) Sturm Separation Theorem, Sturm Comparison Theorem
4) Singular point, Regular Singular Point
5) Lipschitz continuity, Proof of Existence and uniqueness theorem
6) Applications to social sciences and Economics

S.Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Linear Algebra (MTS 2401)**	**Number of Credits : 02**

Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Retrieve basic concepts of real numbers, polynomials over reals and vectors and generalise the concept.
CO2	Interpret various mathematical properties of inner product . Articulate the concept of Eigenvalue and Eigenvectors to study various forms of Matrix Decompositions.
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.
CO4	Explain the concepts of Eigenvalue and Eigenvectors and study various forms of Matrix Decompositions.
CO5	Represent the linear transforms using matrix.
CO6	Create counter examples and support the theory with applicable examples to understand the linear algebra.

Unit No.	Title of Unit and Contents	No of Lectures
I	**Vector Space:** Definitions and Examples. Vector Subspaces. Linear Independence. Basis and Dimensions of a Vector Space. Row and Column Spaces of a matrix. Row rank and Column rank.	**12**
II	**Linear Transformations**: Linear Transformation, representation by a matrix. Kernel and Image of a Linear Transformation. Rank-Nullity theorem. Linear Isomorphism. L (V, W) is a vector space. Dimension of L(V, W) (Statement only), Eigenvalues and eigenvectors.	**12**
III	**Inner Product spaces:** The Euclidean space and dot product.General inner product spaces. Orthogonality, Orthogonal projection onto a line, Orthogonal basis. Gram-Schmidt Orthogonalization.Orthogonal Transformation.	**12**

Text book: S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice Hall of India, New Delhi, 1999.

Learning Resources:

1. M. Artin, Algebra, Prentice Hall of India, New Delhi, (1994).
2. K. Hoffmann and R. Kunze Linear Algebra, Second Ed. Prentice Hall of India New Delhi, (1998).
3. S. Lang, Introduction to Linear Algebra, Second Ed. Springer-Verlag, New Yark, (1986).

4. A. Ramchandra Rao and P. Bhimasankaran, Linear Algebra, Tata McGraw Hill, New Delhi (1994).
5. G. Schay, Introduction to Linear Algebra, Narosa, New Delhi, (1998).
6. L. Smith, Linear Algebra, Springer –Verlag, New York, (1978).
7. G. Strang, Linear Algebra and its Applications.
8. T. Banchoff and J. Werner, Linear Algebra through Geometry. Springer-Verlag, New York, (1984).
9. H. Anton and C. Rorres, Elementary Linear Algebra with Applications, Seventh Ed., Wiley, (1994).

S.Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Vector Calculus (MTS 2402)**	**Number of Credits : 02**

Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Retrieve basic concepts of real analysis and calculus of several variables.
CO2	Interpret divergence and Curl, solenoidal and irrotational vector fields.
CO3	Apply Green's theorem, Stokes theorem and Divergence theorem and solve the problems.
CO4	Explain and apply the concept of curl, gradient and divergence, total differentials.
CO5	Evaluate limit and continuity of vector valued functions, line integral, surface integral.
CO6	Create counter examples and support the theory with applicable examples to understand the vector calculus.

Unit No.	**Title of Unit and Contents**	**No of Lectures**
I	**Vector functions of one variable:** 1) Limit and continuity. 2) Derivatives. 3) Derivability in relation to algebraic operations: constant vector functions. 4) Limits, continuity and partial derivatives of vector function of two and three variables. 5) Total differentials	**12**
II	**Differential operators:** 1) The operator del, scalar and vector fields. 2) Gradient of a scalar point function, properties and its geometrical 3) interpretation. 4) Directional derivatives of a scalar point function. 5) Divergence and curl of a vector point function and its properties. 6) Physical interpretation of Divergence and Curl, Solenoidal and	**12**

	7) Irrotational vector field.	
III	**Vector Integration:** 1) Line Integral. 2) Surface Integral. 3) Volume Integral. 4) Green's theorem with proof. 5) Gauss's Divergence Theorem (statement only). 6) Stokes's Theorem (Statement only), 7) Examples on sphere, cube, cylinder.	**12**

Textbook: V. V. Acharya and M. R. Modak, Vector Calculus, Pdf book

Learning resources:

1. T.M. Apostol, Calculus Vol. II (IInd Edition), John Willey, New York, (1967)
2. Shanti Narayan and P.K. Mittal, A Course of Mathematical Analysis, S. Chand and Co. 12th Edition, 1979.
3. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein (2009). *Basic Multivariable Calculus*, Springer India Pvt. Limited
4. John M. H. Olmsted, Advanced Calculus, Eurasia Publishing House, New Delhi,1970.
5. D.V. Widder, Advanced Calculus (IInd Edition), Prentice Hall of India, New Delhi, 1944.
6. M.R. Spiegel, Advanced Calculus: Schaum Series
7. James Stewart (2012). *Multivariable Calculus* (7th edition). Brooks/Cole. Cengage.
8. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011). *Calculus* (3rd edition), Pearson Education. Dorling Kindersley (India) Pvt. Ltd.
9. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018).*Thomas*' *Calculus* (14th edition). Pearson Education.

S.Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Laplace and Fourier Transform (MTS-2403)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Articulate the Laplace transform of standard functions both from the definition and by using tables.	
CO2	Interpret the appropriate shift theorems, properties in finding Laplace and inverse Laplace transforms.	
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.	
CO4	Explain and apply the properties of Fourier transform and use it to solve differential equations and evaluate nontrivial integrals, Dirichlet conditions.	
CO5	Evaluate real form of Fourier series of standard periodic functions, nontrivial integrals.	
CO6	Create counter examples and support the theory with applicable Laplace and Fourier transforms.	

Unit. No.	Title of Unit and Contents	No of Lectures
I	**The Laplace Transform:** 1. Introduction to Integral Transforms 2. Introduction to improper integrals, Piecewise continuous function, Function of exponential order 3. Definition, Laplace Transform of some elementary functions 4. Some important properties of Laplace Transform 5. Laplace Transform of derivatives, Laplace Transform of Integrals 6. Methods of finding Laplace Transform, Evaluation of Integrals. 7. The Gamma function, Unit step function and Dirac delta function.	**14**
II	**The Inverse Laplace Transform:** 1. Definition, Some inverse Laplace Transform 2. Some important properties of Inverse Laplace Transform. 3. Inverse Laplace Transform of derivative, Inverse Laplace Transform of integrals. 4. Convolution Theorem, Beta function, Evaluation of	**10**

	Integrals.	

III	**The Fourier Transform on R** 1. Fourier Series : An Introduction 2. Introduction to Fourier Transform and Fourier Integral Formula 3. Definition of the Fourier Transform and Examples 4. Fourier Transforms of Generalized Functions and Space of Good Functions 5. Basic Properties of Fourier Transforms 6. Fourier Cosine and Sine Transforms with Examples	**12**

Text books:

1 Schaum's Outline Series - Theory and Problems of Laplace Transform by Murray R. Spiegel. Articles 1, 2, 3.

2 Integral Transforms and Their Applications (Second Edition) by Lokenath Debnath, Dambaru Bhatta

Learning Resources:

1 Fourier Analysis: An introduction, Elias M. Stein & Rami Shakarchi, Princeton University Press.

2 Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd. (1970).Art.12.

3 Joel L. Schiff : The Laplace Transforms - Theory and Applications, Springer-Verlag New York 1999.

S.Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Practical II (MTS 2404)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall the knowledge of a matrix, basic operations, rank and determinant of a matrix.	
	Explain the various applications of the theory of matrices to a wide variety of problems.	
CO2	Explain the terms span, linear independence, basis, dimension, and apply these concepts to various vector spaces and subspaces.	
CO3	Apply the new terms Basis and Dimension and various applications of the theory of matrices to a wide variety of problems.	
CO4		
CO5	Evaluate kernel of linear transformations and nullity of associated vector spaces.	
CO6	Create counter examples for the concept of linear transformations and their properties.	

List of practicals (Compulsory 10 + 2 Activity)

List of Practicals based on MTS 2401: **Linear Algebra :**

1. Vector spaces and subspaces
2. Linearly independent sets and basis
3. Linear transformations
4. Inner product spaces
5. Gram-Scmidt Orthogonalization
6. Eigen values and Eigen vectors.

List of Practicals based on MTS 2402: **Vector Calculus :**

1. Limit, continuity and partial derivatives of vector valued functions
2. Curl, gradient and divergence
3. Line integrals
4. Surface Integrals
5. Green’s theorem
6. Gauss divergence theorem and Stokes’ theorem
7. Applications

List of Practicals based on MTS 2403: **Laplace and Fourier Transform :**

1. Piecewise continuous functions, improper integrals, Laplace transform using shifting properties
2. Properties of Laplace transform
3. Evaluation of integrals using Laplace transform, Gamma function, Dirac delta function, unit step functions
4. Inverse Laplace transform, Convolution, Beta functions
5. Applications of Laplace transform to solve ODE and PDE
6. Fourier series and its applications to evaluate infinite sum
7. Evaluation of Fourier transform of some functions, Fourier Cosine and Sine Transforms
8. Applications of Fourier transform to solve ODE and PDE.

Additional Readings/Projects:

Poisson’s Summation Formula
The Shannon Sampling Theorem
Gibbs’ Phenomenon
Heisenberg’s Uncertainty Principle