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

Subject: Mathematics Paper -1(MTS 2301):Calculus of Several Variables

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

CO1 Evaluate limit and continuity of real valued functions of several variables

CO2 To find partial derivatives using definition and chain rule, discuss the differentiability of the functions and equality of mixed partial derivatives

CO3 Finding out extreme values of real valued functions of several variables and classify the points as local minimum, local maximum or saddle point

CO4 Evaluating multiple integration and using it to find area, volume, center of mass and moment of inertia

Unit	Details	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]

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

Reference Books-

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

Subject Mathematics Paper -2A (MTS 2302): Ordinary Differential Equations

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

CO1 Analyze real world problems to recognize when ordinary differential equations (ODEs) or systems of ODEs are appropriate, formulate problems about the real world situations, creatively model these problems in order to solve the problems using multiple approaches, judge if the results are reasonable, and then interpret and clearly communicate the results.

CO2 Obtain general solutions to first-order, second-order, and higher-order homogeneous and non-homogeneous differential equations by manual and technology-based methods.

CO3 Analyze and apply appropriate methods to solve differential equations; these methods will include, but are not limited to, undetermined coefficients, variation of parameters, reduction of order.

CO4 Effectively apply differential operators and inverse differential operators to solve the higher order differential equations.

Unit	Details	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	**[14]**

	(b) Method of variation of parameter (c) Method of reduction of order	
III	**Higher Order Differential Equations:** 1. Successive integrations, 2. Partial fractions decompositions, 3. Series expansions of operators, 4. The exponential shift rule.	**[08]**

Text Books-

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

Reference books:

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

Subject Mathematics Paper -2B (MTS 2303): Numerical Analysis

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

CO1 Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problem

CO2 Apply numerical methods to obtain approximate solutions to mathematical problems

CO3 Analyse and evaluate the accuracy of common numerical methods

CO4 Analyse error obtained in the numerical solution of the problem

Unit	Details	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. (6) Gauss-Seidel 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	**[12]**

	(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 1st and 2nd order.	

Text Books-

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

Reference Books

1. Brian Bradie (2006), A Friendly Introduction to Numerical Analysis. Pearson.
2. C. F. Gerald & P. O. Wheatley (2008). Applied Numerical Analysis (7th edition),Pearson Education, India.
3. F. B. Hildebrand (2013). Introduction to Numerical Analysis: (2nd edition). Dover Publications.
4. M. K. Jain, S. R. K. Iyengar & R. K. Jain (2012). Numerical Methods for Scientific and Engineering Computation (6th 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

Subject: Mathematics Paper -1 (MTS 2303): Practical

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

CO1 Understand topics discussed on Paper 1 and paper 2/3.
CO2 Solve the problems based on Paper 1 and paper 2/3
CO3 Apply the topics in some situations
CO4 Using a suitable software

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 non homogeneous 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 230: Numerical Analsysis:**

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

Subject: Mathematics Paper -1 (MTS 2401): Linear Algebra

[Credits-2]

Course Outcomes

At the end of this course, students will be able to understand

CO1 Linear dependence and Independence
CO2 Linear transformation and matrices
CO3 Eigen values and eigenvectors
CO4 Orthogonalization

Unit	Details	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.

Reference Books-

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

Subject: Mathematics Paper -1 (MTS 2402): Vector Calculus

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

CO1 Evaluate limit and continuity of vector valued functions
CO2 To find curl, gradient and divergence
CO3 Evaluate line integral, surface integral and applications
CO4 Use of Green's theorem, Stokes theorem and Divergence theorem

Unit	Details	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. Gradient of a scalar point function, properties and its geometrical interpretation. 2) Directional derivatives of a scalar point function. 3) Divergence and curl of a vector point function and its properties. 4) Physical interpretation of Divergence and Curl, Solenoidal and Irrotational vector field.	[12]
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

Reference Books-

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

Subject: Mathematics Paper -2B (MTS-2403): Laplace and Fourier Transform

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

CO1 Understand the existence of Laplace transform and calculate the Laplace transform of standard functions both from the definition and by using tables.

CO2 Analyze and use the appropriate shift theorems, properties in finding Laplace and inverse Laplace transforms and evaluate nontrivial integrals, combine the necessary Laplace transform techniques to solve the differential equations.

CO3 Calculate real form of Fourier series of standard periodic functions and understand the Dirichlet conditions, recognise even and odd functions and use the resulting simplifications for Fourier series and transforms.

CO4 Understand the properties of Fourier transform and use it to solve differential equations, and evaluate nontrivial integrals.

Unit	Details	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 Integrals.	**[10]**
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

Reference books:

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

Subject: Mathematics Paper -1 (MTS 2404): Practical 4

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

CO1 Understand topics discussed on Paper 1 and paper 2/3.
CO2 Solve the problems based on Paper 1 and paper 2/3
CO3 Apply the topics in some situations
CO4 Using a suitable software

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