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

Syllabus under Autonomy for

**S.Y.B.Sc. (Mathematics)**

From academic year 2017-18

| Particulars | Name of Paper | Paper Code | Title of Paper | Type of Paper | No. of Credits |
|---|---|---|---|---|---|
| S.Y. B.Sc. Semester III | Theory Paper - 1 | MTS2301 | Multivariable Differential Calculus | CORE-1 | 3 |
| | Theory Paper - 2 | MTS2302 | Introduction to Linear Algebra-I | CORE- 2 | 3 |
| | Theory Paper - 3 | MTS2303 | Combinatorics | CORE-3 | 2 |
| | Theory Paper-4 | MTS2304 | Ordinary Differential Equation | CORE-4 | 2 |
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| S.Y. B.Sc. Semester IV | Theory Paper - 1 | MTS2401 | Introduction to Linear Algebra-II | CORE-5 | 3 |
| | Theory Paper - 2 | MTS2402 | Multivariable Integral Calculus | CORE-6 | 3 |
| | Theory Paper - 3 | MTS2403 | Laplace and Fourier Transform | CORE-7 | 2 |
| | Theory Paper-4 | MTS2404 | Calculus of complex variables | CORE-8 | 2 |

# S.Y. B.Sc. (Mathematics) Semester III

## Mathematics Paper -1 (MTS2301): Multivariable Differential Calculus

**[Credits-3]**

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|---|---|---|
| **Unit-I** | **Differential Calculus of scalar and vector fields:**<br>1. Functions from R^n to R^m. Scalar and vector fields<br>2. Open balls and open sets<br>3. Limits and continuity<br>4. The derivative of a scalar field with respect to a vector<br>5. Directional derivatives and partial derivatives<br>6. Partial derivatives of higher order<br>7. Directional derivatives and continuity<br>8. The total derivative<br>9. The gradient of a scalar field<br>10. A sufficient condition for differentiability<br>11. A chain rule for derivatives of scalar fields<br>12. Applications to geometry. Level sets. Tangent planes<br>13. Derivatives of vector fields<br>14. Differentiability implies continuity<br>15. The chain rule for derivatives of vector fields<br>16. Matrix form of the chain rule<br>17. Sufficient conditions for the equality of mixed partial derivatives | **14** |
| **Unit-II** | **Applications of the Differential Calculus :**<br>1. Partial differential equations<br>2. A first-order partial differential equation with constant coefficients<br>3. The one-dimensional wave equation<br>4. Derivatives of functions defined implicitly<br>5. Maxima, minima, and saddle points<br>6. Second-order Taylor formula for scalar fields<br>7. The nature of a stationary point determined by the eigenvalues of the Hessian matrix<br>8. Second-derivative test for extrema of functions of two variables<br>9. Extrema with constraints. Lagrange's multipliers<br>10. The extreme-value theorem for continuous scalar fields | **14** |
| **References:** Tom M. Apostol, Calculus Vol II, Second Edition, John Wiley & Sons, Inc. New York , 1991. | | |

## S.Y. B.Sc. (Mathematics) Semester III

### Mathematics Paper -2 (MTS2302): Introduction to Linear Algebra-I

**[Credits-3]**

**Objectives:**

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|---|---|---|
| **Unit-I** | **Vectors :** Definition of points in n-space and its rules, located vectors, equivalent vectors, parallel vectors, scalar or dot product and its properties, perpendicular or orthogonal vectors, norm of a vector, Pythagoras theorem, projection, angle between vectors, Schwarz inequality, triangle inequality, Lines planes and their parametric equations, homogeneous linear equations, row operations, Gauss elimination, echelon form, elementary matrices, linear combinations and linear dependence. | **14** |
| **Unit-II** | **Vectors Spaces :** Definition of field, definition of vector space over a field, vector subspace, Necessary and sufficient condition for subspace, sum and direct sum of subspaces, linear combination, linear span/ generator, convex sets, linear dependence / independence, basis, dimension, coordinates of a vector, basis as a maximal linearly independent set, finite dimensional and infinite dimensional vector spaces, the rank of a matrix, row rank, column rank. | **12** |
| **Unit-III** | **Linear Transformations:** Definition of linear transformation, properties of linear transformations, equality of linear transformations, the coordinates of linear map, the space of linear transformations, kernel and image of a linear transformation, dimension theorem\ rank nullity theorem, rank and linear equations again, dimension of solution set, Matrix of a linear transformation, change of bases, composition of linear transformations, Inverse of a linear transformation, isomorphism, similar matrices. Matrix associated with linear map, linear map associated with matrix. | **15** |

**Textbook:** S. Lang, Introduction to Linear Algebra, Second Ed. Springer.

**References:**


1. Howard Anton, Chris Rorres., Elementary Linear Algebra,John Wiley & Sons, Inc
2. K. Hoffmann and R. Kunze, Linear Algebra, Second Ed. Prentice Hall of India , New Delhi, (1998).
3. G. Strang, Linear Algebra and its Applications, Fourth Ed., Cengage Learning.
4. S. Kumaresan, Linear Algebra A Geometric Approach, Prentice-Hall of India, New Delhi.
5. V. Sahai and V. Bist, Linear Algebra, Narosa.

# S.Y. B.Sc. (Mathematics) Semester III

## Mathematics Paper -3 (MTS2303): Combinatorics

**[Credits-2]**

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| **Unit-I** | (a) Two basic Counting Principles: addition Principle and Multiplication Principle<br>(b) Simple Arrangements and Selections<br>(c) Arrangements and Selections with repetition<br>(d) Distributions<br><br>1. Number of distributions of r distinct objects into n distinct boxes<br><br>2. Number of distributions of r identical objects into n distinct boxes<br><br>3. Binomial Identities: Binomial identities and Multinomial theorem. | **14** |
| **Unit-II** | Inclusion-Exclusion Principle, Counting with Venn diagrams, Inclusion Exclusion formula, Derangements, Simple Examples. | **14** |
| **Unit-III** | Pigeonhole principle | |
| **Unit-IV** | Recurrence Relations: Recurrence relation models, Solution of Linear Homogeneous and non-homogeneous recurrence relations (methods without proof) | |

**Text Book:** Alan Tucker, Applied Combinatorics, Wiley, 1995.

**Reference Book:**

1. Richard A. Brualdi, Introductory Combinatorics, Elsevier,
North-Holland, New York, 1977.
2. V. K. Balakrishnan, Combinatorics, Schuam Series, 1995.

# S.Y. B.Sc. (Mathematics) Semester III

## Mathematics Paper -4 (MTS2304): Ordinary Differential Equation.

**[Credits-3]**

**Objectives:**

| | | |
|---|---|---|
| **Unit-I** | **First order Ordinary differential Equations:**<br>a) Definition, solution, formation of differential equation, order, degree of differential equation.<br>b) Picard's Theorem for existence and uniqueness of solution(statement)<br>c) Methods of solution, Exact differential equation.<br>d) Integration factor, Linear differential equation, Bernoulli's differential equation.<br>e) Orthogonal trajectories, Brachistochrone problem. | **14** |
| **Unit-II** | **Second order Linear Equations:**<br>a) Existence and uniqueness Theorem (statement), General solution, Particular solution,<br>b) General Solution of homogeneous equation: Linear dependence-independence, of solutions, Wronskian.<br>c) Use of known solution to find another.<br>d) Solution of Homogeneous Equation with constant Coefficients | **12** |
| **Unit-III** | **Solution of Non-homogeneous equation:**<br>a) Method of undetermined coefficients<br>b) Method of variation of parameter<br>c) Method of reduction of order<br>d) Variations in mechanical and electrical systems<br>e) Newton's law of gravitation and motion of planets | **15** |
| **Unit-IV** | **Higher order linear equations,**<br>1.Operator methods for finding particular solutions:<br>a) Successive integrations,<br>b) Partial fractions decompositions,<br>c) Series expansions of operators,<br>d) The exponential shift rule.<br>2. Regular Singular points | |

Reference books:


1. George F. Simmons, Differential Equations with Applications And Historical Notes.
2. Simmons and Krantz, Differential Equations.
3. Rainville and Bedient, Elementary Differential equations.
4. Earl A Coddington, Introduction to Ordinary Differential Equations

# S.Y. B.Sc. (Mathematics) Semester IV

## Mathematics Paper -1 (MTS2401): Multivariable Integral Calculus

**[Credits-3]**

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|---|---|---|
| **Unit-I** | **Line Integrals**<br>Introduction ,Paths and line integrals, Other notations for line integrals , Basic properties of line integrals , The concept of work as a line integral ,Line integrals with respect to arc length ,Applications of line integrals , Open connected sets. Independence of the path , The second fundamental theorem of calculus for line integrals , Applications to mechanics ,The first fundamental theorem of calculus for line integrals , Necessary and sufficient conditions for a vector field to be a gradient ,Necessary conditions for a vector field to be a gradient ,Special methods for constructing potential functions , Applications to exact differential equations of first order , Potential functions on convex sets 350 | **14** |
| **Unit-II** | **Multiple Integral**<br><br>Introduction ,Partitions of rectangles. Step functions ,The double integral of a step function ,The definition of the double integral of a function defined and bounded on a rectangle<br>Upper and lower double integrals , Evaluation of a double integral by repeated one-dimensional integration, Geometric interpretation of the double integral as a volume , Integrability of continuous functions, Integrability of bounded functions with discontinuities , Double integrals extended over more general regions, Applications to area and volume ,Further applications of double integrals, Green's theorem in the plane, Some applications of Green's theorem , A necessary and sufficient condition for a two-dimensional vector field to be a gradient, Change of variables in a double integral, Special cases of the transformation formula | **14** |
| **Unit III** | **Surface Integral**<br>Parametric representation of a surface, The fundamental vector product, The fundamental vector product as a normal to the surface, Area of a parametric surface, Surface integrals, Change of parametric representation, Other notations for surface integrals, The theorem of Stokes, The curl and divergence of a vector field, Further properties of the curl and divergence, Extensions of Stokes' theorem, The divergence theorem (Gauss' theorem:), Applications of the divergence theorem | |

**References:** Tom M. Apostol, Calculus Vol II, Second Edition, John Wiley & Sons, Inc. New York , 1991.

# S.Y. B.Sc. (Mathematics) Semester IV

## Mathematics Paper -2 (MTS2402): Introduction to Linear Algebra-II

**[Credits-3]**

**Objectives:**

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|---|---|---|
| **Unit-I** | **Inner Product / Scalar product :**<br><br>Inner product, non degenerate, orthogonal, positive definite, norm as length of a vector, distance between two vectors, Pythagoras theorem, parallelogram law, projection, Schwarz inequality, Bessel inequality, orthogonal and orthonormal bases, orthonormal projection, Gram-Schmidt process of ortogonalization, orthogonal complement, Bilinear maps, the dual space. | **14** |
| **Unit-II** | **Determinants:**<br><br>Determinants of order two, existence of determinants, 3 by 3 and n by n determinants, additional properties of determinants, Cramer's rule, permutations, transposition, sign, determinants in the form of sign and permutations, uniqueness, determinant of transpose, determinant of product, inverse of matrix, the rank of a matrix and sub-determinants, determinants as area and volume. | **12** |
| **Unit-III** | **Eigenvectors and Eigenvalues:**<br><br>Definitions of eigenvectors and eigenvalues eigenspace, the characteristic polynomial, eigenvalues and eigenvectors of symmetric matrices, quadratic form, diagonalization of a symmetric linear map. | **15** |

**Textbook:** S. Lang, Introduction to Linear Algebra, Second Ed. Springer.

**References:**


1. Howard Anton, Chris Rorres., Elementary Linear Algebra,John Wiley & Sons, Inc
2. K. Hoffmann and R. Kunze, Linear Algebra, Second Ed. Prentice Hall of India , New Delhi, (1998).
3. G. Strang, Linear Algebra and its Applications, Fourth Ed., Cengage Learning.
4. S. Kumaresan, Linear Algebra A Geometric Approach, Prentice-Hall of India, New Delhi.
5. V. Sahai and V. Bist, Linear Algebra, Narosa.

# S.Y. B.Sc. (Mathematics) Semester IV

## Mathematics Paper -3 (MTS2403): Laplace and Fourier Transform

**[Credits-2]**

**Objectives:**

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|---|---|---|
| **Unit-I** | **The Laplace Transform:**<br><br>Introduction to improper integrals, Piecewise continuous function, Function of exponential order. Laplace Transform of some elementary functions, Some important properties of Laplace Transform, Laplace Transform of derivatives, Laplace Transform of Integrals, Methods of finding Laplace Transform, Evaluation of Integrals, The Gamma function, Unit step function and Dirac delta function. | **14** |
| **Unit-II** | **The Inverse Laplace Transform:**<br><br>Definition, Some inverse Laplace Transform, Some important properties of Inverse Laplace Transform., Inverse Laplace Transform of derivative, Inverse Laplace Transform of integrals, Convolution Theorem, Beta function, Evaluation of Integrals. | **12** |
| **Unit-III** | **Applications of Laplace Transform:** | **15** |
| **Unit-IV** | **The Fourier Transform on R:**<br><br>Elementary theory of the Fourier transform, Integration of functions on the real lin, Definition of the Fourier transform, The Schwartz space, The Fourier transform on S, The Fourier inversion, The Plancherel formula, Extension to functions of moderate decrease, The Weierstrass approximation theorem. | |
| **Unit-V** | **Applications to some partial differential equations:**<br><br>The time-dependent heat equation on the real line, The steady-state heat equation in the upper half-plane | |

**Reference books:**


1. Schaum's Outline Series - Theory and Problems of Laplace Transform by Murray R. Spiegel. Articles 1, 2, 3.
2. Fourier Analysis: An introduction, Elias M. Stein & Rami Shakarchi, Princeton University Press.
3. Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd. (1970).Art.12.
4. Joel L. Schiff : The Laplace Transforms - Theory and Applications, Springer- Verlag New York 1999.
5. An Introduction to Laplace Transforms and Fourier Series, Springer International Edition, Indian Reprint 2005.

# S.Y. B.Sc. (Mathematics) Semester IV

## Mathematics Paper -4 (MTS2404): Calculus of Complex Variables

**[Credits-2]**

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|---|---|---|
| **Unit-I** | **Topology of Complex Plane:** Neighborhood of a point in the plane, open sets, closed sets, connected sets, regions in the complex plane. Bounded/ unbounded subsets of C. Completeness of C. Cantor intersection theorem. | **14** |
| **Unit-II** | **Functions of a Complex Variable:**Definition and examples. Limit and Continuity. Standard theorems on algebra of limits and algebra of continuous functions. Polynomials and Rational Functions of Complex variable. | **12** |
| **Unit-III** | **Analytic Functions:**Differentiability of a function of complex variable. Comparison with the real differentiability (i.e. as a function of two real variables). Algebra of differentiable functions, chain rule. Definition of analytic function. Cauchy-Riemann equations. Sufficient, condition for analyticity (in terms of C-R equations). | **15** |
| **Unit-IV** | **Examples of analytic functions:**Definition and properties of the following functions of a complex variable: exponential function, trigonometric functions, hyperbolic functions, Logarithmic functions and its branches, complex exponents, inverse trigonometric functions. | |
| **Unit-V** | **Integration:** Contours, Line integrals, Cauchy's theorem (without proof), Cauchy integral formula. Derivative of analytic function, Cauchy's estimate, Liouville's theorem, Fundamentals Theorem of Algebra. | |
| **Unit-VI** | **Residues and Poles:** Taylor series and Laurent series (Statements only). Examples. Zeros of analytic functions. Definition and examples of a function. Residue Theorem. Principal part of a function. Poles, calculation of residues at poles. Evaluation of improper real integrals. | |

**References :**


1. Churchill Ruel V. and Brown James W., Complex Variables and Applications, Fifth edition, McGraw- Hill, 1990.
2. Conway John B., Functions of One Complex Variable, Narosa Publishing House, 1973.
3. Sarason Donald, Notes on Complex Function Theory, Hindustan Book Agency, 1994.
4. Shastri Anant R., An Introduction to Complex Analysis, Macmillan India, 1999.
5. Ahlfors Lars V., Complex Analysis, third edition, McGraw-Hill, 1979.
6. Lang Serge, Complex Analysis, third edition, Springer, 1993
7. Narasimhan R., Complex Analysis in One Variable, Bikhauser Boston, 1985.