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

Syllabus under Autonomy for

S.Y.B.A. (Mathematics)

From academic year 2017-18

Particulars	Name of Paper	Paper Code	Title of Paper	Type of Paper	No. of Credits
S.Y. B.A. Semester III	Theory Paper - 1	MTA2301	Multivariable Differential Calculus	CORE-1	3
	Theory Paper - 2	MTA2302	Introduction to Linear Algebra-I	CORE- 2	3
	Theory Paper - 3	MTA2303	Operation Research	CORE-3	3
	Theory Paper-4	MTA2304	Ordinary Differential Equation	CORE-4	3
	Theory Paper-5	MTA2305	Number Theory	CORE-5	3
S.Y. B.A. Semester IV	Theory Paper - 1	MTA2401	Introduction to Linear Algebra-II	CORE-6	3
	Theory Paper - 2	MTA2402	Multivariable Integral Calculus	CORE-7	3
	Theory Paper - 3	MTA2403	Optimization Techniques	CORE-8	3
	Theory Paper-4	MTA2404	Calculus of complex variables	CORE-9	3
	Theory Paper-5	MTA2405	Computational Geometry	CORE-10	3

S.Y. B.A. (Mathematics) Semester III

Mathematics Paper -1 (MTA2301): Multivariable Differential Calculus

[Credits-3]

Unit-I	**Differential Calculus of scalar and vector fields:** 1. Functions from R^n to R^m. Scalar and vector fields 2. Open balls and open sets 3. Limits and continuity 4. The derivative of a scalar field with respect to a vector 5. Directional derivatives and partial derivatives 6. Partial derivatives of higher order 7. Directional derivatives and continuity 8. The total derivative 9. The gradient of a scalar field 10. A sufficient condition for differentiability 11. A chain rule for derivatives of scalar fields 12. Applications to geometry. Level sets. Tangent planes 13. Derivatives of vector fields 14. Differentiability implies continuity 15. The chain rule for derivatives of vector fields 16. Matrix form of the chain rule 17. Sufficient conditions for the equality of mixed partial derivatives	**24**
Unit-II	**Applications of the Differential Calculus :** 1. Partial differential equations 2. A first-order partial differential equation with constant coefficients 3. The one-dimensional wave equation 4. Derivatives of functions defined implicitly 5. Maxima, minima, and saddle points 6. Second-order Taylor formula for scalar fields 7. The nature of a stationary point determined by the eigenvalues of the Hessian matrix 8. Second-derivative test for extrema of functions of two variables 9. Extrema with constraints. Lagrange's multipliers 10. The extreme-value theorem for continuous scalar fields	**24**
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 (MTA2302): Introduction to Linear Algebra-I

[Credits-3]

Objectives:

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.	**20**
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.	**14**

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.A. (Mathematics) Semester III

Mathematics Paper -3 (MTA2303): Operations Research

[Credits-2]

Unit-I	**Modelling with Linear Programming:** Two variable LP Model, Graphical LP solution, Selected LP Applications, Graphical Sensitivity analysis.	**8**
Unit-II	**The Simplex Method:** LP Model in equation form, Transition from graphical to algebraic solutions, the simplex method, Artificial starting solutions.	**10**
Unit-III	**Duality:** Definition of the dual problem, Primal dual relationship.	**10**
Unit-IV	**Transportation Model:** Definition of the Transportation model. The Transportation algorithm.	**10**
Unit-V	**The Assignment Model:** The Hungarian method, Simplex explanation of the Hungarian method.	**10**

Text Book:

Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.

Ch.2: 2.1, 2.2, 2.3(2.3.4, 2.3.5, 2.3.6).
Ch.3: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 (3.6.1).
Ch.4: 4.1, 4.2.
Ch.5: 5.1, 5.3 (5.3.1, 5.3.2, 5.3.3), 5.4 (5.4.1, 5.4.2).

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operation Research (Eighth Edition) Tata McGraw Hill.

2. J K Sharma, Operations Research (Theory and Applications, second edition, 2006), Macmilan India Ltd.

3. Hira and Gupta, Operation Research.

S.Y. B.A. (Mathematics) Semester III

Mathematics Paper -4 (MTA2304): Ordinary Differential Equations

[Credits-3]

Objectives:

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

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.A. (Mathematics) Semester III

Mathematics Paper -5 (MTA2305): Number Theory

[Credits-3]

Unit-I	**Divisibility:** Divisibility in integers, Division Algorithm, GCD, LCM, Fundamental theorem of Arithmetic, Infinitude of primes, Mersene Numbers and Fermat Numbers.	**8**
Unit-II	**2. Congruences:** Properties of Congruences, Residue classes, complete and reduced residue system, their properties, Fermat's theorem. Euler's theorem, Wilson's theorem, $x2 \equiv -1 \ (mod\ p)$ has a solution if and only if p = 2 or $p \equiv 1 \ (mod\ 4)$, where p is a prime. Linear congruences of degree 1 and Chinese remainder theorem.	**10**
Unit III	**Greatest integer function:** Arithmetic functions Euler's function, the number of divisors d(n), sum of divisors $\sigma\ n$,$\omega\ n\ and\ \Omega(n)$. Multiplicative functions, Mo bius function, Mo bius inversion formula.	**10**
Unit-IV	**Quadratic Reciprocity:** Quadratic residues, Legendre's symbol. Its properties, Law of quadratic reciprocity.	**10**
Unit-V	**Diophantine Equations:** Diophantine Equations ax + by = c and Pythagorean triplets.	**10**

Text Book:

1. I. Niven, H. Zuckerman and H.L. Montgomery, An Introduction to Theory of Numbers, 5th Edition, John Wiley and Sons. (§1.1- §1.3, §2.1- §2.3, §3.1- §3.3, §4.1 -§4.3, §5.1 and §5.3.)

Reference Book:

1. David M. Burton, Elementary Number Theory (Second Ed.), Universal Book Stall, New Delhi, 1991.

S.Y. B.A. (Mathematics) Semester IV

Mathematics Paper -1 (MTA2401): Multivariable Integral Calculus

[Credits-3]

Unit-I	**Line Integrals** 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** 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 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** 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.A. (Mathematics) Semester IV

Mathematics Paper -2 (MTA2402): Introduction to Linear Algebra-II
[Credits-3]

Objectives:

Unit-I	**Inner Product / Scalar product :** 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.	**16**
Unit-II	**Determinants:** 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.	**14**
Unit-III	**Eigenvectors and Eigenvalues:** Definitions of eigenvectors and eigenvalues eigenspace, the characteristic polynomial, eigenvalues and eigenvectors of symmetric matrices, quadratic form, diagonalization of a symmetric linear map.	**18**

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.A. (Mathematics) Semester IV

Mathematics Paper -3 (MTA2403): Optimization Techniques

[Credits-3]

Objectives:

Unit-I	**Network Models:** CPM and PERT, Network representation, Critical Path Computations, Construction of the time schedule, Linear programming formulation of CPM, PERT calculations.	**10**
Unit-II	**Decision Analysis and Games:** Decision under uncertainty, Game theory, some basic terminologies, optimal solution of two person zero sum game, Solution of mixed strategy games, graphical solution of games, linear programming solution of games.	**10**
Unit-III	**Replacement and Maintenance Models:** Introduction, Types of failure, Replacement of items whose efficiency deteriorates with time.	**10**
Unit-IV	**Sequencing Problems:** Introduction, Notation, terminology and assumptions, processing n jobs through two machines, processing jobs through three machines.	**10**
Unit-V	**Classical Optimization Theory:** Unconstrained problems, Necessary and sufficient conditions, Newton Raphson method, Constrained problems, Equality constraints (Lagrangian Method Only).	**8**

Text Book:

1. Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.
Ch.6: 6.5 (6.5.1 to 6.5.5). **Ch.13:** 13.3, 13.4(13.4.1, 13.4.2, 13.4.3).
Ch.18: 18.1(18.1.1, 18.1.2), 18.2 (18.2.1).
2. J K Sharma, Operations Research (Theory and Applications, second Edition, 2006), Macmilan India Ltd.
Ch.17: 17.1, 17.2, 17.3. **Ch.20:** 20.1, 20.2, 20.3, 20.4.

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operation Research (Eighth Edition) Tata McGraw Hill.

2. Hira and Gupta, Operation Research

S.Y. B.A. (Mathematics) Semester IV

Mathematics Paper -4 (MTA2404): Calculus of Complex Variables

[Credits-3]

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.	**10**
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.	**10**
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).	**8**
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.	**8**
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.	**6**
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.	**6**

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.

S.Y. B.A. (Mathematics) Semester IV

Mathematics Paper -5 (MTA2405): Computational Geometry

[Credits-3]

Unit-I	**Two dimensional Transformations:** Introduction, Representation of Points, Transformations and Matrices, Transformation of Points, Transformation of Straight Lines, Midpoint Transformation, Transformation of Parallel Lines, Transformation of Intersecting Lines, Rotation, Reflection, Scaling, Combined Transformations, Transformation of the Unit Square, Solid Body Transformation, Translations and Homogeneous Coordinates, Rotation About an Arbitrary Point, Reflection Through an Arbitrary Line, Projection -A Geometric Interpretation of Homogeneous Coordinates, Overall Scaling, Points at Infinity.	**12**
Unit-II	**Three Dimensional Transformations:** Three Dimensional Scaling and Shearing, Three Dimensional Rotation. Three Dimensional Reflections. Three Dimensional Translations. Multiple Transformations, Rotations about an Axis Parallel to a coordinate axis, Rotation about an Arbitrary Axis in Space, Reflection Through an Arbitrary Plane. Affine and Perspective Geometry, Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformations. Techniques for generating perspective views, Vanishing points.	**12**
Unit-III	**Plane Curves:** Curve representation, non-parametric curves, parametric curves, parametric representation of a circle, parametric representation of an Ellipse, parametric representation of a parabola, parametric representation of a Hyperbola.	**12**
Unit -IV	**Space Curves Bezier curves:** Introduction, definition, properties (without proofs), curve fitting (up to n = 3), equation of the curve in matrix form (up to n = 3).	**12**
Text- Book: D.F. Rogers, J. Alan Adams, Mathematical Elements of Computer Graphics, Second Edition, McGraw-Hill Publishing Company. (§2.2 to 2.20, 3.1 to3.15, 3.17, 4.1 to 4.8, 5.8)		