Deccan Education Society's

Fergusson College (Autonomous), Pune

Department of Mathematics

Syllabus
for
S. Y. B. A. (Mathematics)

To be implemented from academic year 2020-21

Deccan Education Society's
Fergusson College (Autonomous), Pune
Syllabus under Autonomy for S.Y.B.A. (Mathematics)
Under CBCS pattern (2019) *effective from June 2020*

Programme Structure

Sem.	Paper No.	Course code	Title	Credits	CE maximum Marks	ESE maximum Marks	Total maximum Marks
III	SEC- 1 A	MTA 2301	Calculus of Several Variables	3	50	50	100
	SEC-1 B	MTA 2302	Ordinary Differential Equations	3	50	50	100
	SEC-1C	MTA 2303	Operational Research	3	50	50	100
	DSE-1A	MTA 2304	Problem course –I (Paper MTA 2301 and 2302)	4	50	50	100
	DSE-2A	MTA 2305	Number Theory	4	50	50	100
	SEC-1 D	MTA 2306	LaTeX	2	50	50	100
			Total Credits	**19**			**600**
IV	SEC-1E	MTA 2401	Vector Calculus	3	50	50	100
	SEC-1F	MTA 2402	Linear Algebra	3	50	50	100
	SEC-1G	MTA 2403	Optimization Techniques	3	50	50	100
	DSE-1B	MTA 2404	Problem course-II (based on Paper MTA 2401 and 2402)	4	50	50	100
	DSE-2B	MTA 2405	Graph Theory	4	50	50	100
	SEC- 1H	MTA 2406	Scilab	2	50	50	100
			Total Credits	**19**			**600**

S.Y. B.A. Semester III		
Title of the Course and Course Code	**Calculus of Several Variables – MTA2301**	**Number of Credits : 03**
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	**16**
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.	**16**
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.	**16**

Textbook: 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.

Title of the Course and Course Code	**Ordinary Differential Equations – MTS2302**	**Number of Credits : 03**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define differential equations to analyse 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	**16**

	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.	
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	**20**
III	**Higher Order Differential Equations:** 1. Successive integrations, 2. Partial fractions decompositions, 3. Series expansions of operators, 4. The exponential shift rule.	**12**

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.

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.

Title of the Course and Course Code	Operations Research – MTA2303	Number of Credits : 03
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall and articulate basic concepts of LPP. Formulate LPP, Calculate and illustrate graphical solution. Discuss, execute, explain, illustrate, use simplex method.	
CO2	Construct and solve LPP in equation form, translate, formulate graphical to algebraic solution.	
CO3	Define, explain, solve dual LPP. Relate, compare primal and dual LPP.	
CO4	Define, explain, solve transportation model. Use, execute various methods to solve transportation model. Test, verify optimal solution.	
CO5	Define, explain, solve assignment problem. Use, execute various methods to solve assignment problem. Test, verify optimal solution.	
CO6	Recall and articulate basic concepts of LPP. Formulate LPP, Calculate and illustrate graphical solution. Discuss, execute, explain, illustrate, use simplex method.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Modelling with Linear Programming** Two variable LP Model,, Graphical LP solution, Selected LP Applications, Graphical Sensitivity analysis	**10**
II	**The Simplex Method** LP Model in equation form, Transition from graphical to algebraic solutions, the simplex method, Artificial starting solutions	**14**
III	**Duality** Definition of the dual problem, primal dual relationship	**8**
IV	**Transportation Model** Definition of the Transportation model, the Transportation Algorithm	**8**
V	**The Assignment Model** The Hungarian method, Simplex explanation of the Hungarian method	**8**

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)

References:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operations Research (Eighth Edition), Tata McGraw-Hill.
2. J. K. Sharma, Operations Research (Theory and Applications, second edition, 2006), Macmillan India Ltd.
3. Hira and Gupta, Operations Research.

Title of the Course and Course Code	Problem course based on MTA 2301 and MTA2302-MTA2304	Number of Credits : 04
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall basic concepts in Calculus and Differential Equations	
CO2	Interpret partial derivatives, chain rule, differentiability of the functions by solving numerical problems.	
CO3	Using different results and determining integrating factors to solve the ordinary differential equations and apply multiple integrals to find area and volume.	
CO4	Explain continuity, differentiability with the help of examples	
CO5	Evaluate and solve various Mathematical problems	
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	

Title of the Course and Course Code	Number Theory - MTA2305	Number of Credits : 04
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall, define basic concepts of set of integers and divisibility. Discuss, illustrate theorems on divisibility. Solve and verify problems in divisibility.	
CO2	Define, discuss congruence relation. Discuss, illustrate theorems on congruences. Solve and verify problems in congruences. Classify, verify, invent different types of congruence equations.	
CO3	Define, illustrate, examine, verify techniques of numerical calculations	
CO4	Define, illustrate, examine, verify and invent different number theoretic functions.	
CO5	Define, illustrate, examine, verify and invent different congruences laws and , Legendre's symbol.	
CO6	Recall, define basic concepts of set of integers and divisibility. Discuss, illustrate theorems on divisibility. Solve and verify problems in divisibility.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Divisibility** Divisibility in Integers, Division Algorithm, GCD, LCM, Fundamental Theorem of Arithmetic, Infinitude of Primes, Mersenne Numbers and Fermat Numbers	**12**
II	**Congruences** Definition, Properties of Congruences, Residue classes, complete and reduced residue system, their properties, Fermat's theorem. Euler's theorem, Wilsons theorem, $x^2 \equiv 1 \pmod{p}$ has a solution if and only if $p = 2$ or $1 \pmod 4$; where p is a prime. Linear congruences of degree 1 and Chinese remainder	**12**

	theorem.	
III	**Diophantine Equations** $ax + by = c, x^2 + y^2 = z^2$	**6**
IV	**Greatest integer function** Arithmetic functions Euler's function, the number of divisors d(n), sum of divisors σ(n); Ω(n), Multiplicative functions, Mobius function, Mobius inversion formula	**10**
V	**Quadratic Reciprocity** Quadratic residues, Legendre's symbol and its properties, Law of quadratic reciprocity	**8**

Text Book:

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 - §2.5, §3.1 - §3.3, §4.1 -§4.3.)

References:

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

S.Y. B.A. Semester IV		
Title of the Course and Course Code	**Vector Calculus - MTA2401**	**Number of Credits : 03**
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	**16**
II	**Differential operators:**	**16**

	1. The operator del, scalar and vector fields. Gradient of a scalar point function, properties and its geometrical i. 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.	
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.	**16**

Title of the Course and Course Code	**Linear Algebra - MTA2402**	**Number of Credits : 03**
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 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.	**16**
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.	**16**
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.	**16**

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

References:

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. 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).

Title of the Course and Course Code	**Optimization Techniques – MTA2403**	**Number of Credits : 03**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define, explain activities, CPM and PERT. Construct, create, design, verify, execute, test critical path, time schedule. Formulate LPP of CPM and PERT	
CO2	Define, explain, classify, execute, compare different decision criterion. Define, explain, solve game. Discuss properties of game, formulate LPP model.	
CO3	Define, discuss, explain, execute types of failure. Define, explain, classify, execute, replacement policy of items.	
CO4	Define, discuss, explain, execute sequencing problem of job. Construct, create, verify optimal sequence.	
CO5	Define, discuss, explain, and execute unconstrained problems. Discuss, use, solve and construct optimal solution using various methods.	

Unit. No.	**Title of Unit and Contents**	**No. of Lectures**
I	**Network Models** CPM and PERT, Network representation, Critical Path Computations, Construction of the time schedule, Linear programming formulation of CPM, PERT calculations	**10**
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**
III	**Replacement and Maintenance Models** Introduction, Types of failure, Replacement of items whose efficiency deteriorates with	**8**

	time	
IV	**Sequencing Problems** Introduction, Notation, terminology and assumptions, processing n jobs through two machines, processing jobs through three machines	**8**
V	**Classical Optimization Theory** Unconstrained problems, Necessary and sufficient conditions, Newton Raphson method, Constrained problems, Equality constraints(Lagrangian)	**12**

Text Books:

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), Macmillan India Ltd. **Ch.17:** 17.1, 17.2, 17.3. **Ch.20:** 20.1, 20.2, 20.3, 20.4.

References:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operations Research (Eighth Edition), Tata McGraw-Hill.
2. Hira and Gupta, Operations Research.

Title of the Course and Course Code	**Problem course based on MTA 2401 and 2402 - MTA2404**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall basic concepts in Vector Calculus and Linear Algebra	
CO2	Interpret different concepts by solving numerical problems.	
CO3	Using different results and solving various problems	
CO4	Explain different concepts with the help of examples	
CO5	Evaluate and solve various Mathematical problems	

Title of the Course and Course Code	**Graph Theory - MTA2405**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Articulate and retrieve basic concepts of induction, logic and methods of proofs.	
CO2	Define graph and its basic terminology. Categorize, compare verify, examine, create different examples of graphs.	
CO3	Define, classify, illustrate, verify, invent paths and cycles. List, carryout, outline and illustrate theorems on these concepts.	
CO4	Define, classify, illustrate, verify, invent trees. List, carryout, outline and illustrate theorems on these concepts.	

CO5	Define, classify, illustrate, verify, invent planar graphs.
CO6	List, carryout, outline and illustrate theorems on planarity.

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Introduction** Definitions, examples of various types of graphs, degree of a graph, connected graph, sub graphs, isomorphism of graphs, matrix representation of a graph, three puzzles: the eight circles problem, six people at a party, the four cubes problem	**10**
II	**Paths and cycles** Definitions, walk, trail, path, cycle, bounds on number of edges in a simple graph, disconnecting set, edge connectivity, separating set, vertex connectivity, girth, distance, independent edges, connected graph, edge connectivity, Eulerian trail, Eulerian graphs, semi Eulerian graphs, non Eulerian graphs, characterizations of Eulerian graphs, Fleury's algorithm, Hamiltonian cycle, Hamiltonian graphs, semi Hamiltonian graphs, non Hamiltonian graphs, Ore's theorem, Dirac's theorem, the shortest path problem, weighted graph, the Chinese postman problem, the travelling salesman problem.	**18**
III	**Trees** Forest, tree, characterizations of trees, Properties of trees, spanning trees, spanning forest, cycle rank, cut-set rank, complement, fundamental set of cycles, fundamental set of cut-sets, center, counting trees, Cayley's theorem, matrix-tree theorem (without proof), Counting trees, applications -The minimum connector problem, greedy algorithm, enumeration of chemical molecules, electrical networks, searching trees, depth first search algorithm, breadth first search algorithm	**12**
IV	**Planarity** Planar graph, characterization of Planar graph (Kuratowski's theorem), crossing number, Euler's formula, corollaries of Euler's formula, thickness, dual graphs, abstract dual, infinite graph	**8**

Text Book:

R. J. Wilson, Introduction to Graph Theory, 4th Edition, Pearson Education, 2003.
Sections: 2 to 13, 17 to 21.

References:

1. A First Look at Graph Theory, John Clark and Derek Allan Holton, Allied Publishers Ltd., 1991.
2. Graph Theory, Hararay, Narosa Publishers, New Delhi (1989).
3. Graph Theory, Narsing Deo, Prentice Hall of India Pvt. Ltd. (1987).
4. Basic Graph Theory, K. R. Parthsarathy, Tata McGraw-Hill Publisher Co. Ltd.

S.Y. B.A. Semester IV		
Title of the Course and Course Code	**Scilab- MTA2406**	**Number of Credits : 02**

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1	Installation and using Scilab for elementary operations
CO2	Compute various quantities using scilab such as eigenvalues, eiegenvectors etc.
CO3	Manipulate scilab to apply it in various computations such as complex numbers.
CO4	Estimate roots of the polynomials and similar concepts
CO5	Compare different methods to compute same concepts
CO6	Try to write new programmes in Scilab

Unit. No.	Title of Unit and Contents	No. of Lectures
I	Introduction to Scilab, Brief History, Installation for various operating systems, Some Scilab contributions, Basic Syntaxes and Matrix Computations using Scilab,	**12**
II	Solving Linear systems, computing Eigenvalues and eigenvectors, Computations with polynomials and its roots, Special values and complex numbers	**12**
III	Plotting 2D and 3D functions using Scilab, Solving initial value problems using Scilab	**12**