Paper-UGMAT101 GE1: CALCULUS

Full Marks = 70

Course Learning Outcomes: This course will enable the students to:

i) Calculate the limit and examine the continuity and understand the geometrical interpretation of differentiability.

ii) Understand the consequences of various mean value theorems.

iii) Draw curves in Cartesian and polar coordinate systems.

iv) Understand conceptual variations while advancing from one variable to several variables in calculus.

v) Inter-relationship amongst the line integral, double and triple integral formulations.

vi) Realize importance of Green, Gauss and Stokes' theorems in other branches of mathematics.

Question Pattern

i. There shall be 10 MCQs / True-False/Fill in the blanks of 2 marks each. **(10X2=20 Marks)**

ii. 4 short questions of 5 marks each has to be answered out of 6 short questions **(4X5=20 Marks)**

iii. 2 long questions of 15 marks each has to be answered out of 4 long questions **(2X15=30 Marks)**

Unit-I: Sequences, Continuity and Differentiability

Notion of convergence of sequences and series of real numbers, ε-δ definition of limit and continuity of a real valued function; Differentiability and its geometrical interpretation; Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem and their geometrical interpretations, Darboux's theorem.

Unit-II: Expansion of Functions

Successive differentiation and Leibnitz theorem, Maclaurin's and Taylor's theorems for expansion of a function, Taylor's theorem in finite form with Lagrange, Cauchy and Roche–Schlömilch forms of remainder.

Unit-III: Curvature, Asymptotes and Curve Tracing

Curvature; Asymptotes of general algebraic curves, Parallel asymptotes, Asymptotes parallel to axes; Symmetry, Concavity and convexity, Points of inflection, Tangents at origin, Multiple points, Position and nature of double points; Tracing of Cartesian, polar and parametric curves; Envelopes and evolutes.

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Paper-UGMAT202 GE2: DIFFERENTIAL EQUATIONS Full Marks = 70

Sem-II, Paper- GE 2.

Course Learning Outcomes: The course will enable the students to:

i) Understand the genesis of ordinary as well as partial differential equations.

ii) Learn various techniques of getting exact solutions of certain solvable first order differential equations and linear differential equations of second order.

iii) Know Picard's method of obtaining successive approximations of solutions of first order ordinary differential equations, passing through a given point in the plane.

iv) Learn about solution of first order linear partial differential equations using Lagrange's method.

v) Know how to solve second order linear partial differential equations with constant coefficients.

vi) Formulate mathematical models in the form of ordinary and partial differential equations to problems arising in physical, chemical and biological disciplines.

Question Pattern

i. There shall be 10 MCQs / True-False/Fill in the blanks of 2 marks each. **(10X2=20 Marks)**

ii. 4 short questions of 5 marks each has to be answered out of 6 short questions **(4X5=20 Marks)**

iii. 2 long questions of 15 marks each has to be answered out of 4 long questions **(2X15=30 Marks)**

Unit-I: First Order Differential Equations

Basic concepts and genesis of ordinary differential equations, Order and degree of a differential equation, Differential equations of first order and first degree, Equations in which variables are separable, Homogeneous equations, Linear differential equations and equations reducible to linear form, Exact differential equations, Integrating factor, First order higher degree equations solvable for x, y and p, Clairaut's form and singular solutions; Picard's method of successive approximations and the statement of Picard's theorem for the existence and uniqueness of the solutions of the first order differential equations.

Unit-II: Second Order Linear Differential Equations

Statement of existence and uniqueness theorem for the solution of linear differential equations, General theory of linear differential equations of second order with variable coefficients, Solutions of homogeneous linear ordinary differential equations of second order with constant coefficients, Method of variation of parameters and method of undetermined coefficients, Reduction of order, Euler-Cauchy equations, Coupled linear differential equations with constant coefficients.

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Sem–II, Paper—GE. 2.

Unit-III: First Order Partial Differential Equations

Genesis of Partial differential equations (PDE), Concept of linear and non-linear PDEs, Methods of solution of Simultaneous differential equations of the form: $dx/P(x,y,z) = dy/Q(x,y,z) = dz/R(x,y,z)$, Lagrange's method for PDEs of the form: $P(x,y,z)p+Q(x,y,z)q=R(x,y,z)$, where $p=\partial z/\partial x$ and $q=\partial z/\partial y$; Solutions passing through a given curve.

References:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). J. Wiley & Sons
2. B. Rai & D. P. Choudhury (2006). *Ordinary Differential Equations - An Introduction*. Narosa Publishing House Pvt. Ltd. New Delhi.
3. Shepley L. Ross (2007). *Differential Equations* (3rd edition). Wiley.
4. George F. Simmons (2017). *Differential Equations with Applications and Historical Notes* (3rd edition). CRC Press. Taylor & Francis.
5. Ian N. Sneddon (2006). *Elements of Partial Differential Equations*. Dover Publications.

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Paper- UGMAT303 GE3 - REAL ANALYSIS Full Marks = 70

Course Learning Outcomes: This course will enable the students to:

i) Understand basic properties of real number system such as least upper bound property and Order property.

ii) Realize importance of bounded, convergent, Cauchy and monotonic sequences of real numbers, find their limit superior and limit inferior.

iii) Apply various tests to determine convergence and absolute convergence of a series of real numbers.

iv) Learn about Riemann integrability of bounded functions and algebra of R-integrable functions.

v) Determine various applications of the fundamental theorem of integral calculus.

vi) Relate concepts of uniform continuity, differentiation, integration and uniform convergence.

Question Pattern

i. There shall be 10 MCQs / True-False/Fill in the blanks of 2 marks each. **(10X2=20 Marks)**

ii. 4 short questions of 5 marks each has to be answered out of 6 short questions **(4X5=20 Marks)**

iii. 2 long questions of 15 marks each has to be answered out of 4 long questions **(2X15=30 Marks)**

Unit-I: Real Numbers

The set of real numbers (□) as an ordered field, Least upper bound properties of □, Metric property and completeness of □, Archimedean property of □, Dense subsets of □, Nested intervals property; Neighborhood of a point in □, Open sets, limit point of a set, closed and perfect sets in □, connected and compact subsets of □, Heine-Borel theorem.

Unit-II: Convergence of Sequences in □

Bounded and monotonic sequences, Convergent sequence and its limit, Limit theorems, Monotone convergence theorem, Subsequences, Bolzano–Weierstrass theorem, Limit superior and limit inferior, Cauchy sequence, Cauchy's convergence criterion.

Unit-III: Infinite Series

Convergence of a series of positive real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Tests for convergence: Comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's n^{th} root test, Abel's test, Integral test; Alternating series, Absolute and conditional convergence, Leibniz theorem, Rearrangements of series, Riemann's rearrangement theorem.

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Paper-UGMAT404/GE4: ALGEBRA **Full Marks = 70**

Course Learning Outcomes: This course will enable the students to:

i) Employ De Moivre's theorem in a number of applications to solve numerical problems.

ii) Learn about the fundamental concepts of groups, subgroups, normal subgroups, isomorphism theorems, cyclic and permutation groups.

iii) Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank.

iv) Find eigenvalues and corresponding eigenvectors for a square matrix.

v) Understand real vector spaces, subspaces, basis, dimension and their properties.

Question Pattern

i. There shall be 10 MCQs / True-False/ Fill in the blanks of 2 marks each. **(10X2=20 Marks)**
ii. 4 short questions of 5 marks each has to be answered out of 6 short questions **(4X5=20 Marks)**
iii. 2 long questions of 15 marks each has to be answered out of 4 long questions **(2X15=30 Marks)**

Unit-I: Set Theory and Theory of Equations

Sets, Relations, Equivalence relations, Equivalence classes; Finite, countable and uncountable sets; The division algorithm, Divisibility and the Euclidean algorithm, Modular arithmetic and basic properties of congruences; Elementary theorems on the roots of polynomial equations, Imaginary roots, The fundamental theorem of algebra (statement only); The n^{th} roots of unity, De Moivre's theorem for integer and rational indices and its applications.

Unit-II: Groups, Subgroups, Normal Subgroups and Isomorphism Theorems

Definition and properties of a group, Abelian groups, Examples of groups including D_n (dihedral groups), Q_8 (quarternian group), GL(n, R) (general linear groups) and SL(n, R) (special linear groups); Subgroups and examples, Cosets and their properties, Lagrange's theorem and its applications, Normal subgroups and their properties, Simple groups, Factors groups; Group homomorphisms and isomorphisms with properties; First, second and third isomorphism theorems for groups.

Unit-III: Cyclic and Permutation Groups

Cyclic groups and properties, Classifications of subgroup of cyclic groups, Cauchy theorem for finite Abelian groups; Centralizer, Normalizer, Center of a group, Product of two subgroups, Permutation group and properties, Even and odd permutations, Cayley's theorem.

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References:

1. Michael Artin (2014). *Algebra* (2nd edition). Pearson.
2. John B. Fraleigh (2007). *A First Course in Abstract Algebra* (7th edition). Pearson.
3. Stephen H. Friedberg, Arnold J.Insel& Lawrence E. Spence (2003). *Linear Algebra* (4th edition). Prentice-Hall of India Pvt. Ltd.
4. Joseph A. Gallian (2017). *Contemporary Abstract Algebra* (9th edition). Cengage.
5. Kenneth Hoffman & Ray Kunze (2015). *Linear Algebra* (2nd edition). Prentice-Hall.
6. I. N. Herstein (2006). *Topics in Algebra* (2nd edition). Wiley India.
7. Nathan Jacobson (2009). *Basic Algebra* I (2nd edition). Dover Publications.
8. Ramji Lal (2017). *Algebra 1: Groups, Rings, Fields and Arithmetic*. Springer.
9. I.S. Luthar & I.B.S. Passi (2013). *Algebra: Volume 1: Groups*. Narosa.

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