UNIVERSITY OF DELHI
DEPARTMENT OF MATHEMATICS
B.Sc.(Prog.) Analytical Chemistry

Learning Outcomes based Curriculum Framework (LOCF)

2019

SEMESTER WISE PLACEMENT OF THE COURSES

Sem-ester	**Core Course (12)**	**Ability Enhancement Compulsory Course (AEC) (2)**	**Skill Enhancement Course (SEC) (4)**	**Elective Discipline Specific (DSE) (4)**
I				
II	Calculus and Matrices			
III	Abstract Algebra			
IV				
V				
VI				**DSE-1** (i) Differential Equations (with Practicals) OR (ii) Calculus and Geometry

Mathematics Courses Details for B.Sc. (Prog.) Analytical Chemistry:

Semester-II

Paper I: Calculus and Matrices

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: The primary objective of this course is to gain proficiency in differential calculus, and introduce the basic tools of matrices and complex numbers which are used to solve application problems in a variety of settings ranging from chemistry and physics to business and economics. Differential calculus develops the concepts of limit, continuity and derivative, and is fundamental for many fields of mathematics.

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

i) Define and use fundamental concepts of calculus including limits, continuity and differentiability.
ii) Solve systems of linear equations and find eigenvalues and corresponding eigenvectors for a square matrix, and check for its diagonalizability.
iii) Perform operations with various forms of complex numbers to solve equations.

Unit 1: Calculus **(Lectures: 30)**

Graphs of simple concrete functions such as polynomial, Trigonometric, Inverse trigonometric, Exponential and logarithmic functions; Limits and continuity of a function including $\varepsilon-\delta$ approach, Properties of continuous functions including Intermediate value theorem; Differentiability, Successive differentiation, Leibnitz theorem, Recursion formulae for higher derivatives; Rolle's theorem, Lagrange's mean value theorem with geometrical interpretations and simple applications, Taylor's theorem, Taylor's series and Maclaurin's series, Maclaurin's series expansion of functions such as e^x, $\sin x$, $\cos x$, $\log(1+x)$ and $(1+x)^m$; their use in polynomial approximation and error estimation; Functions of two or more variables, Graphs and level curves of functions of two variables, Partial differentiation up to second order.

Unit 2: Matrices **(Lectures: 25)**

Elementary row operations, Row reduction and echelon forms, Solution of systems of linear equations in matrix form, Linear independence and dependence, The rank of a matrix and applications; Elementary linear transformations like shear, translation, dilation, rotation, refection, and their matrix form, The matrix of a general linear transformation; Eigenvectors & eigenvalues of square matrices up to order 3 and diagonalization.

Unit 3: Complex Numbers **(Lectures: 15)**

Geometrical representation of addition, subtraction, multiplication and division of complex numbers; Lines, circles, and discs in terms of complex variables; Statement of the Fundamental Theorem of Algebra and its consequences; De Moivre's theorem and its application to solve simple equations in complex variables.

References:

1. Andreescu, Titu & Andrica Dorin. (2014). *Complex Numbers from A to...Z*. (2nd ed.). Birkhäuser.
2. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). John Wiley & Sons Singapore Pvt. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi.
3. Kolman, Bernard, & Hill, David R. (2001). *Introductory Linear Algebra with Applications* (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.
4. Lay, David C., Lay, Steven, R., & McDonald Judi, J. (2016). *Linear Algebra and its Applications* (5th ed.). Pearson.
5. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). *Thomas*' *Calculus* (13th ed.). Pearson Education, Delhi. Indian Reprint 2017.

Additional Reading:

i. Prasad, Gorakh (2016). *Differential Calculus* (19th ed.). Pothishala Pvt. Ltd. Allahabad.

Teaching Plan (Paper I: Calculus and Matrices):

Week 1: Graphs of simple concrete functions such as polynomial, Trigonometric, Inverse trigonometric, Exponential and logarithmic functions. [5] Sections 1.1, 1.2, 1.3, 7.2, 7.3, and 7.6.
Weeks 2 and 3: Limits and continuity of a function including $\varepsilon-\delta$ approach, Properties of continuous functions including Intermediate value theorem. [2] Chapter 1.
Week 4: Differentiability, Successive differentiation, Leibnitz theorem, Recursion formulae for higher derivatives. [5] Chapter 3 (Sections 3.2, 3.3, and 3.6), and Exercise 26, Page 184.
Week 5: Rolle's theorem, Lagrange's mean value theorem with geometrical interpretations and simple applications, Taylor's theorem, Taylor's series and Maclaurin's series, Maclaurin's expansion of functions such as e^x, $\sin x$, $\cos x$, $\log(1+x)$ and $(1+x)^m$; their use in polynomial approximation and error estimation. [5] Chapter 4 (Sections 4.2, and 4.3). [2] Chapter 9 (Sections 9.8, and 9.9).
Week 6: Functions of two or more variables, Graphs and Level curves of functions of two variables, Partial differentiation up to second order. [2] Chapter 13 (Sections 13.1, and 13.3).
Weeks 7 and 8: Elementary row operations, Row reduction and echelon forms, Solution of systems of linear equations in matrix form, Linear independence and dependence, The rank of a matrix and applications. [4] Chapter 1 (Sections 1.1, 1.2, 1.4, 1.6, 1.7). [3] Chapter 6 [Section 6.6 (Pages 287-291)].
Weeks 9 and 10: Elementary linear transformations like shear, translation, dilation, rotation, refection, and their matrix form, The matrix of a general linear transformation. [4] Chapter 1 (Sections 1.8, 1.9).
Week 11: Eigenvectors & eigenvalues of square matrices up to order 3 and diagonalization.
[4] Chapter 5 (Sections 5.1 to 5.3)
Weeks 12 to 14: Geometrical representation of addition, subtraction, multiplication and division of complex numbers; Lines, Circles, Discs in terms of complex variables; Statement of the Fundamental Theorem of Algebra and its consequences; De Moivre's theorem and its application to solve simple equations in complex variables. [5] Appendix A.7.
[1] Chapter 1 (Section 1.2), Chapter 2 (Sections 2.1.2 to 2.1.4, and 2.2.3), and Chapter 3 (3.5.1, 3.5.2, and 3.6.1)

Semester-III

Paper II: Abstract Algebra

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: The objective of this course is to introduce the fundamental theory of groups, rings and vector spaces, a major part of abstract algebra, which is an essential tool in number theory, geometry, topology and has applications in cryptography, coding theory, quantum chemistry and physics.
Course Learning Outcomes: The course will enable the students to:

i) Recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups etc;
ii) Explain the significance of the notion of cosets, normal subgroups, and of factor groups;
iii) Understand the fundamental concepts of Rings, Fields, Subrings, Integral domains, Vector spaces over a field, and linear transformations.

Unit 1: Groups **(Lectures: 35)**
Definition and examples of groups, Abelian and non-Abelian groups, The group $\mathbb{Z}_n$ of integers under addition modulo *n* and the group $U(n)$ of units under multiplication modulo *n*; Cyclic groups from sets of numbers, Group of n^{th} roots of unity, The general linear group; Elementary properties of groups; Groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square; The permutation group Sym (*n*), and properties of permutations; Order of an element, Subgroups and its examples, Subgroup tests, Cyclic subgroup, Center of a group, Properties of cyclic groups; Cosets and its properties, Lagrange's theorem, Index of a subgroup; Definition and examples of normal subgroups.

Unit 2: Rings **(Lectures: 15)**
Definition and examples of rings, Commutative and noncommutative rings, Properties of rings, Subrings and ideals; Integral domains and fields, Examples of fields: $\mathbb{Z}_p, \mathbb{Q}, \mathbb{R}$, and $\mathbb{C}$.

Unit 3: Vector Spaces and Linear Transformations **(Lectures: 20)**
Definition and examples of vector spaces, Subspaces, Linear independence, Basis and dimension of a vector space; Linear transformations, Null spaces, Ranges and illustrations of the rank-nullity theorem.

References:

1. Gallian, Joseph. A. (2013). *Contemporary Abstract Algebra* (8th ed.). Cengage Learning India Private Limited, Delhi. Fourth impression, 2015.
2. Friedberg, Stephen H., Insel, Arnold J., & Spence, Lawrence E. (2003). *Linear Algebra* (4th ed.). Prentice-Hall of India Pvt. Ltd. New Delhi.

Additional Readings:

i. Beachy, John A., & Blair, William D. (2006). *Abstract Algebra* (3rd ed.). Waveland Press.
ii. Lay, David C., Lay, Steven, R., & McDonald Judi, J. (2016). *Linear Algebra and its Applications* (5th ed.). Pearson.

Teaching Plan (Paper III: Abstract Algebra):

Weeks 1 and 2: Groups**:** Definition and examples of abelian and nonabelian groups, The group $\mathbb{Z}_n$ of integers under addition modulo *n* and the group $U(n)$ of units under multiplication modulo *n*; Cyclic groups from sets of numbers, Group of n^{th} roots of unity, The general linear group; Elementary properties of groups. [1] Chapter 2.
Week 3: Groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square; The permutation group Sym (n), and properties of permutations.
[1] Chapter 1, Chapter 5 (Examples 1 to 7 and illustrations of Theorems 5.1 to 5.7 without proofs).
Weeks 4 and 5: Order of an element, Subgroups and its examples, Subgroup tests, Cyclic Subgroup, Center of a group, Properties of cyclic groups. [1] Chapters 3, and 4.
Week 6: Cosets and its properties, Lagrange's Theorem, Index of a subgroup.
[1] Chapter 7 up to Corollary 4, Page 149.
Week 7: Normal subgroups: Definition, examples and characterizations, Factor groups.
[1] Chapter 9 (Theorem 9.1, and Theorem 9.2 (Statement only) up to Examples 11, Page 189.
Weeks 8 and 9: Definition and examples of rings, commutative and noncommutative rings, Properties of rings, Subrings and ideals. [1] Chapter 12, and Chapter 14 up to Example 4, Page 268.
Week 10: Integral domains and fields, Examples of fields: $\mathbb{Z}_p, \mathbb{Q}, \mathbb{R},$ and $\mathbb{C}$.
[1] Chapter 13 up to Example 10, Page 258.
Weeks 11 and 12: Definition and examples of vector spaces, Subspaces, Linear independence, Basis and dimension of a vector space. [1] Chapter 19.
Weeks 13 and 14: Linear transformations, Null spaces, Ranges and illustrations of the rank-nullity theorem. [2] Chapter 2 (Section 2.1).

Semester-VI
Discipline Specific Elective (DSE) Course -Mathematics

DSE-1: Differential Equations (with Practicals)
OR
DSE-2: Calculus and Geometry

DSE-1: Differential Equations (with Practicals)

Total Marks: 150 (Theory: 75, Internal Assessment: 25 and Practical: 50)
Workload: 4 Lectures, 4 Practicals (per week) **Credits:** 6 (4+2)
Duration: 14 Weeks (56 Hrs. Theory + 56 Hrs. Practical) **Examination:** 3 Hrs.

Course Objectives: This course helps the students to develop skills and knowledge of standard concepts in ordinary and partial differential equations and also provide the standard methods for solving differential equations.
Course Learning Outcomes: The student will be able to:
- i) Solve the exact, linear and Bernoulli equations and find orthogonal trajectories.
- ii) Apply the method of variation of parameters to solve linear differential equations.
- iii) Formulate and solve various types of partial differential equations of first and second order.

Unit 1: First Order Ordinary Differential Equations **(Lectures: 16)**
First order exact differential equations, Integrating factors, Rules to find an integrating factor ; Linear equations and Bernoulli equations, Orthogonal trajectories and oblique trajectories; Basic theory of higher order linear differential equations, Wronskian, and its properties; Solving differential equation by reducing its order.

Unit 2: Second Order Linear Differential Equations **(Lectures: 16)**
Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation; Simultaneous differential equations.

Unit 3: Partial Differential Equations **(Lectures: 24)**
Partial differential equations**:** Basic concepts and definitions with mathematical problems; First order partial differential equations**:** Classification, Construction, Geometrical interpretation, Method of characteristics and general solutions, Canonical forms and method of separation of variables; Second order partial differential equations**:** Classification, Reduction to canonical forms; Linear second order partial differential equations with constant coefficients**:** Reduction to canonical forms with general solutions.

References:

1. Myint-U, Tyn & Debnath, Lokenath. (2007). *Linear Partial Differential Equation for Scientists and Engineers* (4th ed.). Springer, Third Indian Reprint, 2013.
2. Kreyszig, Erwin (2011). *Advanced Engineering Mathematics* (10th ed.). John Wiley & Sons, Inc. Wiley India Edition 2015.
3. Ross, Shepley L. (1984). *Differential Equations* (3rd ed.). John Wiley & Sons, Inc.

Additional Reading:

i. Ross, Clay C. (2004). *Differential Equations*: *An Introduction with Mathematica®* (2nd ed.). Springer.
ii. Sneddon, I. N. (2006). *Elements of Partial Differential Equations*, Dover Publications. Indian Reprint.

Practical / Lab work to be performed in a Computer Lab:

Use of computer algebra systems (CAS), for example Mathematica/MATLAB/ Maple/Maxima/Scilab, etc., for developing the following programs:

1) Solution of first order differential equation.
2) Plotting of second order solution family of differential equation.
3) Plotting of third order solution family of differential equation.
4) Solution of differential equation by variation of parameter method.
5) Solution of systems of ordinary differential equations.
6) Solution of Cauchy problem for first order PDE.
7) Plotting the characteristics for the first order PDE.
8) Plot the integral surfaces of a given first order PDE with initial data.

Teaching Plan (Theory Paper: DSE-1: Differential Equations):

Week 1: First order ordinary differential equations: Basic concepts and ideas.
[3] Chapter 1 (Sections 1.1, and 1.2). [2] Chapter 1 (Sections 1.1, and 1.2).
Week 2: First order exact differential equations. Integrating factors and rules to find integrating factors.
[3] Chapter 2 (Sections 2.1, and 2.2). [2] Chapter 1 (Section 1.4).
Week 3 and 4: Linear equations and Bernoulli equations, Orthogonal trajectories and oblique trajectories; Basic theory of higher order linear differential equations, Wronskian, and its properties; Solving a differential equation by reducing its order.
[3] Chapter 2 (Sections 2.3, and 2.4), Chapter 3 (Section 3.1), and Chapter 4 (Section 4.1).
Week 5 and 6: Linear homogenous equations with constant coefficients. Linear non-homogenous equations. [3] Chapter 4 (Sections 4.2, 4.3, and 4.6). [2] Chapter 2 (Section 2.2).
Week 7: The method of variation of parameters, The Cauchy-Euler equation. [3] Sections 4.4, and 4.5.
Week 8: Simultaneous differential equations. [3] Chapter 7 (Sections 7.1, and 7.3).
Week 9: Partial differential equations: Basic concepts and definitions with mathematical problems, Classification of first order partial differential equations**.** [1] Chapter 2 (Sections 2.1, and 2.2).
Week 10: Construction and Geometrical interpretation of first order partial differential equations.
[1] Chapter 2 (Sections 2.3, and 2.4).
Week 11: Method of characteristics, General solutions of first order partial differential equations.
[1] Chapter 2 (Section 2.5).
Week 12: Canonical forms and method of separation of variables for first order partial differential equations. [1] Chapter 2 (Sections 2.6, and 2.7).
Week 13: Classification of second order partial differential equations, reduction to canonical forms.
[1] Chapter 4 (Sections 4.1, and 4.2).
Week 14: Second order partial differential equations with constant coefficients, General solutions.
[1] Chapter 4 (Sections 4.3, and 4.4).

DSE-2: Calculus and Geometry

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Course Objectives: The objectives of this course are to consider applications of derivatives for sketching of curves and conics and application of definite integrals for calculating volumes of solids of revolution, length of plane curves and surface areas of revolution which are helpful in understanding their applications in plenary motion, design of telescope and to many real-world problems.

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

i) Sketch curves in a plane using its mathematical properties in the different coordinate systems of reference.
ii) Compute area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas.
iii) Be well versed with conics and quadric surfaces so that they should able to relate the shape of real life objects with the curves/conics.

Unit 1: Derivatives for Graphing and Applications (Lectures:25)
The first derivative test for relative extrema, Concavity and inflection points, Second derivative test for relative extrema, Curve sketching using first and second derivative tests, Limits to infinity and infinite limits, Graphs with asymptotes, L'Hôpital's rule; Parametric representation of curves and tracing of parametric curves (except lines in $\mathbb{R}^3$), Polar coordinates and tracing of curves in polar coordinates.

Unit 2: Volume and Area of Surfaces (Lectures: 20)
Volumes by slicing disks and method of washers, Volumes by cylindrical shells, Arc length, Arc length of parametric curves, Area of surface of revolution; Reduction formulae.

Unit 3: Geometry and Vector Calculus (Lectures: 25)
Techniques of sketching conics, Reflection properties of conics, Rotation of axes and second degree equations, Classification into conics using the discriminant; Introduction to vector functions and their graphs, Operations with vector-valued functions, Limits and continuity of vector functions, Differentiation of vector-valued functions, gradient, divergence, curl and their geometrical interpretation; Spheres, Cylindrical surfaces; Illustrations of graphing standard quadric surfaces like cone, ellipsoid.

References:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). John Wiley & Sons Singapore Pvt. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi.
2. Strauss, M. J., Bradley, G. L., & Smith, K. J. (2007). *Calculus* (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Sixth impression 2011.

Additional Reading:

i. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). *Thomas' Calculus* (13th ed.). Pearson Education, Delhi. Indian Reprint 2017.

Teaching Plan (DSE-2: Calculus and Geometry):

Weeks 1 and 2: The first derivative test for relative extrema, Concavity and inflection points, Second derivative test for relative extrema, Curve sketching using first and second derivative tests.
[2] Chapter 4 (Section 4.3).
Weeks 3 and 4: Limits to infinity and infinite limits, Graphs with asymptotes, Vertical tangents and cusps, L'Hôpital's rule. [2] Chapter 4 (Sections 4.4 and 4.5). [1] Chapter 3 (Section 3.3).
Week 5: Parametric representation of curves and tracing of parametric curves (except lines in $\mathbb{R}^3$), Polar coordinates and the relationship between Cartesian and polar coordinates. Tracing of curves in polar coordinates. [2] Chapter 9 [Section 9.4 (pages 471 to 475)]. [1] Chapter 10 (Section 10.2).
Weeks 6 and 7: Volumes by slicing disks and method of washers. Volumes by cylindrical shells, Arc length, Arc length of parametric curves. [1] Chapter 5 (Sections 5.2, 5.3 and 5.4).
Week 8: Area of surface of revolution. [1] Chapter 5 (Section 5.5).
Week 9: Reduction formulae, and to obtain the iterative formulae for the integrals of the form**:** $\int \sin^n x\,dx,\ \int \cos^n x\,dx,\ \int \tan^n x\,dx, \int \sec^n x\,dx,$ and $\int \sin^m x \cos^n x\,dx.$
[1] Chapter 7 [Sections 7.2 and 7.3 (Pages 497 to 503)].
Weeks 10 and 11: Techniques of sketching conics**:** Parabola, Ellipse and Hyperbola. [1] Section 10.4.
Week 12: Reflection properties of conics, Rotation of axes, second degree equations and their classification into conics using the discriminant. [1] Chapter 10 (Sections 10.4 and 10.5).
Week 13: Vector-valued functions, Differentiation of vector-valued functions, Gradients, Divergence, Curl and their geometrical interpretation. [1] Sections 12.1, 12.2, and 15.1.
Week 14: Spheres, Cylindrical surfaces. Illustrations of graphing standard quadric surfaces like cone, ellipsoid. [1] Chapter 11 (Sections 11.1, and 11.7).