TEACHING PLAN for Academic Year 2021 – 2022
Course: B.Sc.(H) Mathematics

PAPER: Calculus
SEMESTER: I
SESSION: 2021 – 2022 (Odd Semester)
TEACHER NAME: Ms. Pooja Khoda

- **SYLLABUS as per guidelines**

Unit 1: Derivatives for Graphing and Applications

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' Hopital' s rule; Applications in business, economics and life sciences; Higher order derivatives, Leibniz rule.

Unit 2: Sketching and Tracing of Curves

Parametric representation of curves and tracing of parametric curves (except lines in $\mathbb{R}^3$), Polar coordinates and tracing of curves in polar coordinates; Techniques of sketching conics, Reflection properties of conics, Rotation of axes and second-degree equations, Classification into conics using the discriminant.

Unit 3: Volume and Area of Surfaces

Volumes by slicing disks and method of washers, Volumes by cylindrical shells, Arc length, Arc length of parametric curves, Area of surface of revolution; Hyperbolic functions; Reduction formulae.

Unit 4: Vector Calculus and its Applications

Introduction to vector functions and their graphs, Operations with vector functions, Limits and continuity of vector functions, Differentiation and integration of vector functions; Modelling ballistics and planetary motion, Kepler's second law; Unit tangent, Normal and binormal vectors, Curvature.

- **COURSE DESCRIPTION/OBJECTIVE**

The primary objective of this course is to introduce the basic tools of calculus and geometric properties of different conic sections which are helpful in understanding their applications in planetary motion, design of telescope and to the real-world problems. Also, to carry out the hand on sessions in computer lab to have a deep conceptual understanding of the above tools to widen the horizon of students' self-experience.

- **TEACHING TIME(No. Of Weeks): 14 weeks (Approximately)**

- **CLASSES**

The course is organized around daily lectures as per the time table scheduled. Students will be given readings cum notes each week to help them follow the course content. These readings will be discussed in class in detail.

- **WEEK WISE BREAK UP OF SYLLABUS**

Week 1: 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.
[3] Chapter 4 (Section 4.3)

Week 2: Limits to infinity and infinite limits, Graphs with asymptotes, Vertical tangents and cusps, L'Hopital's rule.
[3] Chapter 4 (Sections 4.4 and 4.5).

Week 3: Applications of derivatives in business, economics and life sciences. Higher order derivatives and Leibniz rule for higher order derivatives for the product of two functions.
[3] Chapter 4 (Section 4.7).
[2] Chapter 5 (Sections 5.1, 5.2 and 5.4).

Week 4: 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.
[3] Chapter 9 [Section 9.4 (Pages 471 to 475)].
[1] Chapter 10 (Sections 10.1, and 10.2 up to Example 2, Page 707).

Weeks 5 and 6: Tracing of curves in polar coordinates. Techniques of sketching conics: parabola, ellipse and hyperbola.
[1] Sections 10.2 (Pages 707 to 717), and 10.4 up to Example 10 Page 742)].

Week 7: Reflection properties of conics, Rotation of axes, second degree equations and their classification into conics using the discriminant.
[1] Sections 10.4 (Pages 742 to 744) and 10.5.

Weeks 8 and 9: 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 10: Area of surface of revolution; Hyperbolic functions.
[1] Sections 5.5 and 6.8.

Week 11: Reduction formulae, and to obtain the iterative formulae for the integrals of the form: $\int \sin^n x \, dx, \int \cos^n x \, dx, \int \tan^n x \, dx, \int \sec^n x \, dx.$
[1] Chapter 7 [Sections 7.2 and 7.3 (Pages 497 to 503)].

Week 12: Introduction to vector functions and their graphs, Operations with vector functions, Limits and continuity of vector functions, Differentiation and tangent vectors.
[3] Chapter 10 (Sections 10.1 and 10.2 up to Page 504).

Week 13: Properties of vector derivatives and integration of vector functions; modelling ballistics and planetary motion, Kepler's second law.
[3] Chapter 10 [Sections 10.2 (Pages 505 to 511) and 10.3].

Week 14: Unit tangent, Normal and binormal vectors, Curvature.
[1] Sections 12.4 and 12.5.

- **ASSESSMENT**

Internal Assessment: 25 Marks (Group Presentation and Class Test)

- **ESSENTIAL READINGS**

[1] Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). Calculus (10th ed.). John Wiley & Sons Singapore Pte. Ltd. Indian Reprint (2016) by Wiley India Pvt. Ltd. Delhi.
[2] Prasad, Gorakh (2016). Differential Calculus (19th ed.). Pothishala Pvt. Ltd. Allahabad.
[3] Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). Calculus (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

- **SUGGESTED READINGS**

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

PAPER: Group Theory -II
SEMESTER: V
SESSION: 2021 – 2022 (Odd Semester)
TEACHER NAME: Ms. Pooja Khoda

- **SYLLABUS as per guidelines**

Unit 1

Automorphisms and Properties Automorphism, inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups, Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.

Unit 2

External and Internal Direct Products of Groups , External direct products of groups and its properties, The group of units modulo n as an external direct product, Applications to data security and electric circuits; Internal direct products, Classification of groups of order Kc, where K is a prime; Fundamental theorem of finite abelian groups and its isomorphism classes.

Unit 3

Group Action

Group actions and permutation representations; Stabilizers and kernels of group actions; Groups acting on themselves by left multiplication and consequences; Conjugacy.

Unit 4: Sylow Theorems and Applications

Conjugacy classes, Class equation, K-groups, Sylow theorems and consequences, Applications of Sylow theorems; Finite simple groups, Nonsimplicity tests; Generalized Cayley's theorem, Index theorem, Embedding theorem and applications.

- **COURSE DESCRIPTION/OBJECTIVE**

The course will develop an in-depth understanding of one of the most important branch of the abstract algebra with applications to practical real-world problems. Classification of all finite abelian groups (up to isomorphism) can be done.

- **TEACHING TIME (No. Of Weeks): 14 weeks (Approximately)**

Week 1: Automorphism, Inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups.[2] Chapter 6 (Pages 135 to 138).

Week 2: Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups. [2] Exercises 1 to 4 on Page 181, and Exercises 62, 68 on Page 204. [2] Chapter 9 (Theorem 9.4 and Example 17).

Week 3: External direct products of groups and its properties, The group of units modulo n as an external direct product, Applications to data security and electric circuits.[2] Chapter 8.

Week 4: Internal direct products, Classification of groups of order Kc, where K is a prime. [2] Chapter 9 (Section on internal direct products, Pages 195 to 200).

Week 5: Statement of the Fundamental theorem of finite abelian groups, The isomorphism classes of Abelian groups. [2] Chapter 11.

Weeks 6 and 7: Group actions and permutation representations; Stabilizers and kernels of group actions. [1] Chapter 1 (Section 1.7), Chapter 2 (Section 2.2) and Chapter 4 (Section 4.1, except cycle decompositions).

Weeks 8 and 9: Groups acting on themselves by left multiplication and consequences; Conjugacy. [1] Chapter 4 [Section 4.2 and Section 4.3 (Pages 125-126)].

Week 10: Conjugacy classes, Class equation, K-groups. [2] Chapter 24 (Pages 409 to 411).

Weeks 11 and 12: State three Sylow theorems and give their applications. [2] Chapter 24 (Pages 412 to 421).

Weeks 13 and 14: Finite simple groups, Nonsimplicity tests; Generalized Cayley's theorem, Index theorem, Embedding theorem and applications; Simplicity of A_5. [2] Chapter 25.

- **CLASSES**

The course is organized around daily lectures as per the time table scheduled. Students will be given readings cum notes each week to help them follow the course content. These readings will be discussed in class in detail.

WEEK WISE BREAK UP OF SYLLABUS

- **ASSESSMENT**

Internal Assessment: 25 Marks (Group Assignment and Class Test)

- **ESSENTIAL READINGS**

1.Dummit, David S., & Foote, Richard M. (2016). *Abstract Algebra* (3rd ed.). Student Edition. Wiley India.

2. Gallian, Joseph. A. (2013). *Contemporary Abstract Algebra* (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.

- **SUGGESTED READINGS**

Rotman, Joseph J. (1995). *An Introduction to The Theory of Groups* (4th ed.) Springer-Verlag, New York.

PAPER: Differential Equations
SEMESTER: II
SESSION: 2021– 2022 (Jan 2022- April 2022) (Even Semester)
TEACHER NAME: Ms. Pooja Khoda

- **SYLLABUS as per guidelines**

Unit 1: Differential Equations and Mathematical Modelling
Differential equations and mathematical models, Order and degree of a differential equation, Exact differential equations and integrating factors of first order differential equations, Reducible second order differential equations, Applications of first order differential equations to acceleration-velocity model, Growth and decay model.

Unit 2: Population Growth Models
Introduction to compartmental models, Lake pollution model (with case study of Lake Burley Griffin), Drug assimilation into the blood (case of a single cold pill, case of a course of cold pills, case study of alcohol in the bloodstream), Exponential growth of population, Limited growth of population, Limited growth with harvesting.

Unit 3: Second and Higher Order Differential Equations
General solution of homogeneous equation of second order, Principle of superposition for a homogeneous equation; Wronskian, its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, Method of undetermined coefficients, Method of variation of parameters, Applications of second order differential equations to mechanical vibrations.
Unit 4: Analysis of Mathematical Models
Interacting population models, Epidemic model of influenza and its analysis, Predator-prey model and its analysis, Equilibrium points, Interpretation of the phase plane, Battle model and its analysis.

- **COURSE DESCRIPTION/OBJECTIVE**

The main objective of this course is to introduce the students to the exciting world of differential equations, mathematical modelling and their applications.

- **TEACHING TIME (No. Of Weeks): 14 weeks (Approximately)**

- **CLASSES**

The course is organized around daily lectures as per the time table scheduled. Students will be given readings cum notes each week to help them follow the course content. These readings will be discussed in class in detail.

WEEK WISE BREAK UP OF SYLLABUS
Weeks 1 and 2: Differential equations and mathematical models, Order and degree of a differential equation, Exact differential equations and integrating factors of first order differential equations, Reducible second order differential equations.
[2] Chapter 1 (Sections 1.1 and 1.6).
[3] Chapter 2.

Week 3: Application of first order differential equations to acceleration-velocity model, Growth and decay model.
[2] Chapter 1 (Section 1.4, Pages 35 to 38), and Chapter 2 (Section 2.3).
[3] Chapter 3 (Section 3.3, A and B with Examples 3.8, 3.9).

Week 4: Introduction to compartmental models, Lake pollution model (with case study of Lake Burley Griffin).
[1] Chapter 2 (Sections 2.1, 2.5 and 2.6).

Week 5: Drug assimilation into the blood (case of a single cold pill, case of a course of cold pills, Case study of alcohol in the bloodstream).
[1] Chapter 2 (Sections 2.7 and 2.8).

Week 6: Exponential growth of population, Density dependent growth, Limited growth with harvesting.
[1] Chapter 3 (Sections 3.1 to 3.3).

Weeks 7 to 9: General solution of homogeneous equation of second order, Principle of superposition for a homogeneous equation; Wronskian, its properties and applications; Linear homogeneous and non-homogeneous equations of higher order with constant coefficients; Euler's equation.
[2] Chapter 3 (Sections 3.1 to 3.3).

Weeks 10 and 11: Method of undetermined coefficients, Method of variation of parameters; Applications of second order differential equations to mechanical vibrations.
[2] Chapter 3 (Sections 3.4 (Pages 172 to 177) and 3.5).

Weeks 12 to 14: Interacting population models, Epidemic model of influenza and its analysis, Predator-prey model and its analysis, Equilibrium points, Interpretation of the phase plane, Battle model and its analysis.
[1] Chapter 5 (Sections 5.1, 5.2, 5.4 and 5.9), and Chapter 6 (Sections 6.1 to 6.4).

- **ASSESSMENT**

Internal Assessment: 25 Marks (Group Assignment and Class Tests)

- **ESSENTIAL READINGS**

[1] Barnes, Belinda & Fulford, Glenn R. (2015). Mathematical Modelling with Case Studies, Using Maple and MATLAB (3rd ed.). CRC Press, Taylor & Francis Group.
[2] Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equation and Boundary Value Problems: Computing and Modeling (5th ed.). Pearson Education.
[3] Ross, Shepley L. (2004). Differential Equations (3rd ed.). John Wiley & Sons. India

- **SUGGESTED READINGS**

[1] Ross, Clay C. (2004). *Differential Equations*: *An Introduction with Mathematica*, (2nd ed.). Springer.

PAPER: Complex Analysis
SEMESTER: VI
SESSION: 2021 – 2022 (Even Semester)
TEACHER NAME: Ms. Pooja Khoda

- **SYLLABUS**

Unit 1: Analytic Functions and Cauchy Riemann Equations

Functions of complex variable, Mappings; Mappings by the exponential function, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulae, Cauchy Riemann equations, Sufficient conditions for differentiability; Analytic functions and their examples.

Unit 2: Elementary Functions and Integrals

Exponential function, Logarithmic function, Branches and derivatives of logarithms, Trigonometric function, Derivatives of functions, Definite integrals of functions, Contours, Contour integrals and its examples, Upper bounds for moduli of contour integrals,

Unit 3: Cauchy's Theorems and Fundamental Theorem of Algebra

Antiderivatives, Proof of antiderivative theorem, Cauchy Goursat theorem, Cauchy integral formula; An extension of Cauchy integral formula, Consequences of Cauchy integral formula, Liouville ' s theorem and the fundamental theorem of algebra.

Unit 4: Series and Residues

Convergence of sequences and series, Taylor series and its examples; Laurent series and its examples, Absolute and uniform convergence of power series, Uniqueness of series representations of power series, Isolated singular points, Residues, Cauchy's residue theorem, residue at infinity; Types of isolated singular points, Residues at poles and its examples.

- **COURSE DESCRIPTION/OBJECTIVE**

  This course aims to introduce the basic ideas of analysis for complex functions in complex variables with visualization through relevant practicals. Emphasis has been laid on Cauchy's theorems, series expansions and calculation of residues.

- **TEACHING TIME (No. Of Weeks): 14 weeks (Approximately)**

- **CLASSES**

  The course is organized around daily lectures as per the time table scheduled. Students will be given readings cum notes each week to help them follow the course content. These readings will be discussed in class in detail.

- **WEEK WISE BREAK UP OF SYLLABU**

Week 1: Functions of complex variable, Mappings, Mappings by the exponential function. [1] Chapter 2 (Sections 12 to 14).

Week 2: Limits, Theorems on limits, Limits involving the point at infinity, Continuity. [1] Chapter 2 (Sections 15 to 18).

Week 3: Derivatives, Differentiation formulae, Cauchy-Riemann equations, Sufficient conditions for differentiability. [1] Chapter 2 (Sections 19 to 22).

Week 4: Analytic functions, Examples of analytic functions, Exponential function. [1] Chapter 2 (Sections 24 and 25) and Chapter 3 (Section 29).

Week 5: Logarithmic function, Branches and Derivatives of Logarithms, Trigonometric functions.[1] Chapter 3 (Sections 30, 31 and 34).

Week 6: Derivatives of functions, Definite integrals of functions, Contours. [1] Chapter 4 (Sections 37 to 39).

Week 7: Contour integrals and its examples, upper bounds for moduli of contour integrals. [1] Chapter 4 (Sections 40, 41 and 43).

Week 8: Antiderivatives, proof of antiderivative theorem. [1] Chapter 4 (Sections 44 and 45).

Week 9: State Cauchy Goursat theorem, Cauchy integral formula. [1] Chapter 4 (Sections 46 and 50).

Week 10: An extension of Cauchy integral formula, Consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra. [1] Chapter 4 (Sections 51 to 53).

Week 11: Convergence of sequences, Convergence of series, Taylor series, proof of Taylor's theorem, Examples. [1] Chapter 5 (Sections 55 to 59).

Week 12: Laurent series and its examples, Absolute and uniform convergence of power series, uniqueness of series representations of power series.[1] Chapter 5 (Sections 60, 62, 63 and 66).

Week 13: Isolated singular points, Residues, Cauchy's residue theorem, Residue at infinity. [1]: Chapter 6 (Sections 68 to 71).

Week 14: Types of isolated singular points, Residues at poles and its examples. [1] Chapter 6 (Sections 72 to 74).

- **ASSESSMENT**

  Internal Assessment: 25 Marks (Group Assignment, Class Test and Presentation)

- **ESSENTIAL READINGS**

1.Brown, James Ward, & Churchill, Ruel V. (2014). *Complex Variables and Applications* (9th ed.). McGraw-Hill Education. New York. (13th ed.). Pearson Education, Delhi. Indian Reprint 2017.

- **Additional Readings:**

1.Bak, Joseph & Newman, Donald J. (2010). *Complex Analysis* (3rd ed.). Undergraduate Texts in Mathematics, Springer. New York.

2.Zills, Dennis G., & Shanahan, Patrick D. (2003). *A First Course in Complex Analysis with Applications*. Jones & Bartlett Publishers, Inc.

3.Mathews, John H., & Howell, Rusell W. (2012). *Complex Analysis for Mathematics and Engineering* (6th ed.). Jones & Bartlett Learning. Narosa, Delhi. Indian Edition.
