Syllabus template

Semester: 2	
Programme : Mathematics	
Course : Complex Numbers & Applications of Calculus and ordinary differential equations	
Paper code: B1MT230211T	Credits: 4
Hours/week : 4 hours	
Category: Core/MDC/SEC/VAC : Minor	
Theory / Practical / Composite : Theory	
No of Modules 2	

Course Overview: Complex Numbers & Applications of Calculus and ordinary differential equations

This course provides a foundational understanding of key mathematical concepts essential for higher studies in science and engineering. It is divided into two major modules: (i) Algebra and Analysis, and (ii) Ordinary Differential Equations. The course aims to build analytical thinking, problem-solving skills, and the ability to model and interpret mathematical phenomena using appropriate methods.

The module on Complex Numbers & Applications of Calculus introduces the **theory and operations of complex numbers**, emphasizing both their **algebraic and geometric representations**. Students explore basic operations—addition, multiplication, division, modulus, argument, and conjugate—along with properties like the **triangle inequality**. Through **De Moivre's theorem**, learners understand the relationships between trigonometric and exponential forms of complex numbers and apply these to solve equations and evaluate powers and roots. The unit on **functions of a complex variable** extends to exponential, trigonometric, logarithmic, and hyperbolic functions, helping students appreciate the rich interconnections between real and complex analysis.

The **calculus section** focuses on practical applications of differentiation in geometry and curve analysis. Students learn to determine **tangents, normals, curvature, asymptotes, concavity**, and **points of inflection**, developing the ability to analyze the local and global behavior of curves. These topics strengthen understanding of how calculus aids in the study of shapes, motion, and optimization.

The module on ordinary differential equations forms the analytical core of the course, introducing **ordinary differential equations** (ODEs) as mathematical tools for modeling dynamic systems. Students begin by learning the **formation of ODEs** from real-world examples in geometry, physics, and engineering, gaining insight into how differential equations describe rates of change.This module covers various **techniques for solving first-order ODEs**, including **exact and non-exact equations**, the use of **integrating factors**, and **Bernoulli's and Clairaut's equations**. Students also examine **first-order equations of higher degree**, learning to derive general and singular solutions.In the study of **second-order linear differential equations**, emphasis is placed on both **homogeneous and non-homogeneous forms**, including **Cauchy–Euler equations** and equations with **variable coefficients**. The course further explores **Wronskian determinants** to test linear independence and introduces the **method of variation of parameters** as a general approach for solving non-homogeneous equations.

Course Outcome: Complex Numbers & Applications of Calculus and ordinary differential equations

1. Recall fundamental operations on complex numbers including modulus, argument, conjugate, and their algebraic and geometric interpretations.

2. Apply De Moivre's theorem to compute powers and roots of complex numbers and solve related trigonometric and exponential problems.
3. Evaluate and manipulate functions of a complex variable (exponential, logarithmic, trigonometric, and hyperbolic functions) to solve mathematical problems.
4. Demonstrate understanding of geometric inequalities (e.g., triangle inequality) and analyze them in the complex plane.
5. Derive and analyze the equations of tangents and normals to curves using differential calculus.
6. Determine curvature and radius of curvature for given curves and interpret their geometrical significance.
7. Identify and analyze asymptotes, concavity, and points of inflection for functions to study their graphical behavior.
8. Formulate ordinary differential equations from simple physical, geometrical, or engineering situations.
9. Solve first-order exact and non-exact differential equations using integrating factors and apply them in different problems.
10. Solve first-order higher degree ODEs (such as Clairaut's equations) and analyze their general and singular solutions.
11. Derive and solve second-order linear homogeneous and non-homogeneous differential equations using standard methods.
12. Evaluate the Wronskian to determine linear independence of solutions of differential equations.
13. Solve linear non-homogeneous equations with constant coefficients and Cauchy–Euler equations to model applied problems. 14.
14.Apply the method of variation of parameters to solve second-order ODEs with variable coefficients and analyze the results.
Prerequisites: *Basic knowledge about any prior course*
SYLLABUS: Complex Numbers, Application of Calculus & Ordinary Differential Equations

UNIT/Module	CONTENT	HOURS or NUMBER OF CLASSES	CO Mapping	COGNITIVE LEVEL
I.	Complex numbers [13] (Basic Operations: Multiplication, Division; Modulus and Argument; Complex Conjugate and its properties), Triangle Inequality [3], De-Moivre's theorem and its applications [3], Functions of a complex variable: Exponential, sine, cosine, logarithms and complex powers, Hyperbolic Functions and related problems,[7]	13 classes	CO1, CO2, CO3, CO4	K1, K2 K3, K4 K5
II.	Application of Calculus [12] Tangent and Normal [3], Curvature (3). Asymptotes (Cartesian equation only)[3], concavity and inflection points	12 classes	CO5, CO6, CO7	K3, K4, K5

	[3]			
III.	Ordinary Differential equations [27]: Formation of ode - exemplification from various fields (2) First order ode: Exact differential equations, Non-exact differential equations & Integrating factors (no proof) (4) Linear ode and Bernoulli's equation(2).First order higher degree ordinary differential equations; Clairaut's equation: general solutions (3).General solution of linear homogeneous differential equations of second order [2] , Wronskian and related problems [2].Linear non-homogeneous equations with constant co-efficients; Cauchy Euler equation[5]; Second order linear differential equations with variable coefficients ; method of variation of parameters [7]	27 classes	CO8, CO9, CO10, CO11 CO12, CO13, CO14	K2, K3 K4, K5

Text Books
1. Classical Analysis—S.K.Mapa.
2. Higher Algebra (Linear and Abstract)—S.K.Mapa.
3. Differential Equations—Maity,Ghosh..
4. Application of Calculus—Maity,Ghosh
Suggested readings
1. Introduction to Real Analysis—Bartle, Sherbert
2.
3.
Web Resources
1. https://youtu.be/JOfnCCNj4gQ
2. https://youtu.be/_LX1p0VFkp4
3. https://youtu.be/0FLrxud3fgU
4. https://ocw.mit.edu/courses/18-03-differential-equations-spring-2010/
Evaluation: Theory CIA: 20+5+5=30 Semester Exam: 70
Paper Structure for Theory Semester Exam : 7 questions each carrying 10 marks out of 12/13 questions

Course outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	Recall fundamental operations on complex numbers including modulus, argument, conjugate, and their algebraic and geometric interpretations.	K1, K2

CO2	Apply De Moivre's theorem to compute powers and roots of complex numbers and solve related trigonometric and exponential problems.	K3, K4
CO3	Evaluate and manipulate functions of a complex variable (exponential, logarithmic, trigonometric, and hyperbolic functions) to solve mathematical problems.	K3, K5
CO4	Demonstrate understanding of geometric inequalities (e.g., triangle inequality) and analyze them in the complex plane.	K2, K4
CO5	Derive and analyze the equations of tangents and normals to curves using differential calculus.	K3
CO6	Determine curvature and radius of curvature for given curves and interpret their geometrical significance.	K3, K4
CO7	Identify and analyze asymptotes, concavity, and points of inflection for functions to study their graphical behavior.	K4, K5
CO8	Formulate ordinary differential equations from simple physical, geometrical, or engineering situations	K2, K3
CO9	Solve first-order exact and non-exact differential equations using integrating factors and apply them in different problems.	K3
CO10	Solve first-order higher degree ODEs (such as Clairaut's equations) and analyze their general and singular solutions.	K3, K4
CO11	Derive and solve second-order linear homogeneous and non-homogeneous differential equations using standard methods.	K3, K5
CO12	Evaluate the Wronskian to determine linear independence of solutions of differential equations.	K3, K4
CO13	Solve linear non-homogeneous equations with constant coefficients and Cauchy–Euler equations to model applied problems.	K3, K4, K5
CO14	Apply the method of variation of parameters to solve second-order ODEs with variable coefficients and analyze the results.	K3, K5