



Syllabus
Gyanmanjari Institute Of Technology
Semester-3(B.Tech)

Subject: Complex Variables and Partial Differential Equations (BET2XX13218)

Type of course: Major (Core)

Prerequisite: Partial differentiation, chain rule, and multiple integration, Differential Equations. Complex Numbers.

Rationale: This course provides the essential mathematical tools for engineering modeling, fluid dynamics, heat transfer, and structural mechanics. Moving beyond basic calculus, students learn to formulate and solve Partial Differential Equations (PDEs) that govern real-world systems changing across time and space. Additionally, the study of complex variables and conformal mapping allows students to transform irregular geometric boundaries into simplified domains for easier practical analysis. Emphasizing a Proficient Learning Method (PLM), the course focuses on active engineering applications, software-assisted visualization, and hands-on case studies over theoretical proofs equipping students with the diagnostic and analytical skills necessary to simulate and optimize complex technical systems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks		Total Marks
CI	T	P	C	SEE	CCE	
4	0	0	4	100	50	150

Course Content:

Sr. No	Course Content	Hrs.	% Weightage												
1	ComplexNumbers&Elementary Functions Polarformofcomplexnumbers,powers,androots,Differentiation ofcomplex variables, Cauchy-Riemann equations, and analyticity, Harmonic functions and finding the harmonic conjugate, Exponential, trigonometric, and logarithmic functions and their properties.	12	20%												
	<table><tr><th>SrNo.</th><th>EvaluationMethods</th><th>SEE</th><th>CCE</th></tr><tr><td>1</td><td>Harmonic Conjugate Reconstruction Exam Validatingharmonicprofilesand finding their corresponding orthogonalprofilestobuildan analytic function.</td><td>10</td><td></td></tr><tr><td>2</td><td>SeparationTest:</td><td>10</td><td></td></tr></table>			SrNo.	EvaluationMethods	SEE	CCE	1	Harmonic Conjugate Reconstruction Exam Validatingharmonicprofilesand finding their corresponding orthogonalprofilestobuildan analytic function.	10		2	SeparationTest:	10	
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2	SeparationTest:	10													

Complex Variables and Partial Differential Equations

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		Splitting transcendental complex configurations into real and imaginary structures to locate zeros.				
	3	The Analyticity Audit: Students receive a flawed mathematical proof claiming a non-differentiable function is analytic. They must act as "auditors," isolate the logic/derivative errors using Cauchy-Riemann equations, and write a report correcting it.		10		
		Total:	20	10		
	Description of CCE: The Analyticity Audit (10 Marks): A diagnostic workflow task where students assume the role of an auditor to inspect flawed mathematical claims, isolate structural "logic cracks" using Cauchy-Riemann criteria, and file a correction report.					
2	Conformal Mappings & Complex Integration Conformal mappings, Möbius transformations, and their properties, Contour integrals and the Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem, and the Maximum-Modulus theorem (without proof).				12	20%

convergence, and functions given by power series, Taylor series and Maclaurin series.

SrNo.	Evaluation Methods	SEE	CCE
1	The "Taylor Approximation" Lab A technology-assisted, open-ended practical exam focusing on uniform convergence and approximation errors.	20	
2	Maclaurin Expansion Short Video Students record a 3-minute screen-share or whiteboard video explaining how to expand a multi-element complex function into its Maclaurin series.		10
Total:		20	10

- **Description of SEE: Taylor Approximation Software Lab (20 Marks):** A technology-assisted practical examination utilizing Desmos to evaluate uniform convergence boundaries and compute polynomial approximation errors dynamically.
- **Description of CCE: Maclaurin Expansion Short Video (10 Marks):** An interactive digital assignment where students record a 3-minute screen-share or whiteboard lecture explaining the multi-element expansion mechanics of complex power series.

First-Order Partial Differential Equations (PDEs)

Formation and concepts of first-order partial differential equations. Solutions of first-order linear and nonlinear PDEs, Derive PDE from Eliminating arbitrary constant and Functions, Lagrange method, Charpit's Method for solving non-linear first-order PDEs.

SrNo.	Evaluation Methods	SEE	CCE
1	Formulation Test An applied algorithmic exam testing the generation of differential surfaces via parameter elimination, Lagrange grouping/multipliers, and Charpit's non-linear solvers.	20	



2	Complete vs. General Integral Workbook A problem-solving assignment assessing the clear execution of using a complete integral along with an arbitrary function relation to construct a general solution.		10
	Total:	20	10

- **Description of SEE: Formulation & Charpit Solver Test (20 Marks):** An applied algorithmic exam checking a student's ability to generate differential surfaces by eliminating arbitrary parameters and executing Charpit's non-linear steps
- **Description of CCE: Complete vs. General Integral Workbook (10 Marks):** A structured problem-solving log tracking the systematic bridging of complete integrals with arbitrary function configurations to formulate general PDE solutions.

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Higher-Order Linear PDEs & Boundary Value Problems.

Homogeneous and nonhomogeneous linear partial differential equations of second and higher order, Complementary function (CF) and Particular Integral (PI) methods, Classification of second-order linear equations; understanding initial and boundary conditions, Separation of variables method applied to simple problems in Cartesian coordinates.

SrNo.	Evaluation Methods	SEE	CCE
1	Technical Case Study An applied engineering report where students model a real-world physical system into a second-order PDE and solve it completely using the separation of variables method.	20	
2	Vivavoce		10
	Total:	20	10

- **Description of SEE: Technical Case Study Report (20 Marks):** A professional capstone report where students model an engineering infrastructure system (e.g., heat conduction or wave propagation) into a second-order PDE and solve it completely

12

20%



Suggested Specification table with Marks:

Distribution of Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage %	10%	15%	30%	25%	10%	10%

Course Outcomes:

After learning the course, the students should be able to:	
CO1	Verify functions for analyticity using Cauchy-Riemann equations and construct harmonic conjugate to map steady-state physical fields (like fluid flow or heat).
CO2	Apply Möbius and conformal transformation to map complex geometric boundaries, and solve complex contour integrations using the Cauchy Integral Formula.
CO3	Expand complex-valued functions into Taylor and Laurent series to evaluate singularities and approximate system behaviors.
CO4	Formulate and solve first-order linear and non-linear partial differential equations (PDEs) using Lagrange and Charpit methods to model dynamic surfaces.
CO5	Classify second-order linear PDEs and apply the separation of variables method to solve boundary value problems representing physical phenomena (e.g., heat equation, wave equation).

Instructional Method:

The course will be delivered using traditional classroom teachings supported by active and application-based learning strategies appropriate for engineering students. In addition to blackboard teaching, the instructor will use:

- **Open-book learning and guided problem-solving** for conformal mappings and boundary transformations, utilizing textbooks and notebooks to focus on application over memorization.
- **Diagnostic and Audit-based practice** for identifying "logic cracks" in derivative proofs and verification profiles through "The Analyticity Audit".
- **Graphical and visual methods** for visualizing complex power series convergence limits, pole singularities, and 3D surface profiles of PDEs.

- **Active Learning Assignments (ALA)** including rapid conceptual checkpoints for qualitative theorems and structured problem-solving workbooks for tracking complete versus general integrals.
- **Mini-projects and engineering case studies** like the "Technical Case Study Report" to model and solve real-life physical infrastructure equations using the separation of variables method.
- **Interactive assessments** through "Practical Performance Exams," screen-share video lectures, and live "Viva Voce" defenses to reinforce conceptual understanding.
- **Internal evaluation** based on prescribed SEE and CE components, tracking student progress via audit reports, convergence logs, programming files, and oral defenses.

Reference Books:

[1]. Advanced Engineering Mathematics, By Erwin Kreyszig, Wiley India Pvt. Ltd. [2].

Higher Engineering Mathematics by B.S. Grewal (Khanna Publishers)

[3]. Calculus and Analytic Geometry by G.B. Thomas and R.L. Finney (Pearson). [4].

Basic Engineering Mathematics by John Bird (Elsevier/Newnes)

Suggestive Rubrics:

Suggestive Assessment Guidelines:
Module I: ALA: The Analyticity Audit (10 Marks) • 10 Marks: All logic and derivative errors successfully diagnosed and corrected using Cauchy-Riemann equations with professional-grade engineering justifications. • 08 Marks: Most errors identified using Cauchy-Riemann equations; corrections are accurate but justifications are brief. • 05 Marks: Identified basic derivative errors but struggled with complex harmonic conjugate reconstruction or multi-variable logic. • 02 Marks: Minimal identification of errors; unable to provide correct alternatives or apply analyticity conditions. • 00 Marks: Not submitted.



Module2:**ALA: "Property Showdown" Quiz (10 Marks)**

- **10 Marks:** Flawless qualitative reasoning and perfect conceptual mastery demonstrated across all short-answer theorem questions.
- **08 Marks:** Strong conceptual understanding shown; answers are accurate but missing minor theoretical nuances.
- **05 Marks:** Understands standard computational applications but lacks verbal or conceptual precision for qualitative theorems like Liouville's or Maximum-Modulus.
- **02 Marks:** Limited comprehension of theorem conditions; unable to identify basic qualitative properties.
- **00 Marks:** Not submitted.

Module3:

- **CCE/ALA: Maclaurin Expansion Short Video (10 Marks)**

- **10 Marks:** Highly professional 3-minute video delivery; flawless verbal and visual breakdown of multi-element complex function series expansion.
- **08 Marks:** Successful video walkthrough; series expansion steps are accurate but the oral explanation lacks fluid transitions.
- **05 Marks:** Calculated expansion terms correctly in the recording, but the explanation fails to articulate the underlying convergence logic clearly.
- **02 Marks:** Minimal effort in explanation; video content contains significant mathematical errors during expansion steps.
- **00 Marks:** Not submitted.

- **SEE/ESE: The "Taylor Approximation" Software Lab (20 Marks)**

- **20 Marks:** Exceptional technology-assisted logs tracking uniform convergence boundaries and computing polynomial approximation errors dynamically with perfect precision.
- **16 Marks:** Accurate use of software to generate power series; convergence logs are correct but lack deep error analysis.
- **10 Marks:** Generates standard Taylor/Maclaurin plots but fails to accurately trace or evaluate uniform convergence zones near boundaries.
- **05 Marks:** Poor execution of software tools; visualization does not match the mathematical limits of the series.
- **00 Marks:** Not submitted.

Module4:

- **CCE/ALA: Complete vs. General Integral Workbook (10 Marks)**

- **10 Marks:** Flawless workbook tracking; impeccable path logic mapping the connection



- between complete integrals and arbitrary functions to generate general PDE solutions.
- **08 Marks:** Correct workbook formatting and mathematical steps with minor notation gaps in dependency tracking.
- **05 Marks:** Workbook includes standard integrations but lacks a clear logical flow when constructing the general solution.
- **02 Marks:** Poorly structured notes; fail to correctly link variables or eliminate arbitrary parameters.
- **00 Marks:** Not submitted.

• **SEE/ESE: Formulation Test (20 Marks)**

- **20 Marks:** Flawless construction of differential surfaces using Lagrange multipliers and accurate execution of Charpit's non-linear solver steps.
- **16 Marks:** Successful generation of PDEs; auxiliary equations are mostly correct with minor computational errors.
- **10 Marks:** Formulates basic linear PDEs from parameter elimination but breaks down entirely during non-linear Charpit setups.
- **05 Marks:** Significant difficulty formulating equations; unable to set up Lagrange grouping parameters accurately.
- **00 Marks:** Not submitted.

Module 5:

• **CCE/ ALA: Viva Voce (10 Marks)**

- **10 Marks:** Confident livedefense; flawless use of technical vocabulary to explain second-order PDE classifications and initial/boundary values.
- **08 Marks:** Accurate oral descriptions of solution steps; minor hesitation when explaining physical boundary states.
- **05 Marks:** Can identify basic PDE categories but requires constant prompting to explain how initial conditions apply to the solution.
- **02 Marks:** Unable to define core engineering math terms; cannot verbally justify solution steps.
- **00 Marks:** Not submitted.

• **SEE/ESE: Technical Case Study (20 Marks)**

- **20 Marks:** Exceptional engineering report; perfectly models a physical system into a second-order PDE and solves it completely via separation of variables.
- **16 Marks:** Mathematically sound case study; applies separation of variables accurately but has minor slips calculating final Fourier coefficients.
- **10 Marks:** Correctly classifies the physical PDE (heat/wave) but struggles to match boundary parameters to complete the engineering solution.
- **05 Marks:** Poor system modeling; the selected solution technique does not align with the given boundary conditions.



- 00 Marks: Not submitted.

