Gyanmanjari
Innovative University

Syllabus
GyanmanjariInstituteOfTechnology
Semester-3(B.Tech)

Subject: ComplexVariablesandPartialDifferential Equations(BET2XX13218)

Typeof course: Major(Core)

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

Rationale: This courseprovides the essential mathematical tools forengineeringmodeling, 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 mappingallows 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.

TeachingandExamination Scheme:

TeachingScheme			Credits	ExaminationMarks		TotalMarks
CI	T	P	C	SEE	CCE	
4	0	0	4	100	50	150

Course Content:

<table>
<tr><th>Sr. No</th><th>Course Content</th><th>Hrs.</th><th>% Weightage</th></tr>
<tr><td>1</td><td>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.

<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></td><td>12</td><td>20%</td></tr>
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<tr><td></td><td>Splittingtranscendentalcomplex configurations into real and imaginarystructurestolocate zeros.</td><td></td><td></td></tr>
<tr><td>3</td><td>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-Riemannequations,and writeareportcorrectingit.</td><td></td><td>10</td></tr>
<tr><td></td><td>Total:</td><td>20</td><td>10</td></tr>
</table>
Description of CCE: The Analyticity Audit (10 Marks): A diagnostic workflow task where students assume the role of an auditortoinspectflawedmathematicalclaims,isolatestructural "logic cracks" using Cauchy-Riemann criteria, and file a correction report.
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<td>2</td>
<td>
ConformalMappings&Complex Integration

Conformalmappings,Möbiustransformations,andtheirproperties, ContourintegralsandtheCauchy-Goursattheorem(withoutproof), Cauchy Integral formula (without proof), Liouville's theorem, and the Maximum-Modulus theorem (without proof).

<table>
<tr><th>SrNo.</th><th>EvaluationMethods</th><th>SEE</th><th>CCE</th></tr>
<tr><td>1</td><td>An open-book written assignment</td><td>20</td><td></td></tr>
<tr><td>2</td><td>"Property Showdown" Quiz A fast-paced, conceptual multiple-choiceorshort-answer quiz focusing strictly on qualitativetheorems.</td><td></td><td>10</td></tr>
<tr><td></td><td>Total:</td><td>20</td><td>10</td></tr>
</table>
Description of CCE: "Property Showdown" Quiz (10 Marks): A rapid-fire, high-engagement short-answer checkpointtestingastudent'squalitativegraspofcoreabstract theorems (such as Liouville's and Maximum-Modulus principles).
</td>
<td>12</td>
<td>20%</td>
</tr>
<tr>
<td>3</td>
<td>Sequences,Series,andPowerSeries

Sequences,series,andconvergencetests,Powerseries,uniform</td>
<td>12</td>
<td>20%</td>
</tr>
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convergence.andfunctionsgivenbypowerseries,Taylorseriesand Maclaurin series.

SrNo.	EvaluationMethods	SEE	CCE
1	**The"TaylorApproximation" Lab** A technology-assisted, open-endedpracticalexamfocusing onuniformconvergenceand approximation errors.	20	
2	**MaclaurinExpansionShort Video** Students record a 3-minute screen-shareorwhiteboardvideo explaining how to expand a multi-elementcomplexfunction into its Maclaurin series.		10
	Total:	**20**	**10**

- **Description of SEE: Taylor Approximation Software Lab (20 Marks):** A technology-assisted practical examination utilizingDesmostoevaluateuniformconvergenceboundaries and compute polynomial approximation errors dynamically.
- **Description of CCE: Maclaurin Expansion Short Video (10 Marks):** An interactive digital assignment where studentsrecord a 3-minute screen-share or whiteboard lecture explaining themulti-elementexpansionmechanicsofcomplexpower series.

4

First-OrderPartialDifferentialEquations (PDEs)

Formationandconceptsoffirst-orderpartialdifferentialequations. Solutions of first-order linear and nonlinear PDEs, Derive PDE from Eliminating arbitrary constant and Functions, Langrage method, Charpit's Method for solvingnon-linear first-order PDEs.

12

20%

SrNo.	EvaluationMethods	SEE	CCE
1	**Formulation Test** An applied algorithmic exam testing the generation of differential surfaces via parameterelimination,Lagrange grouping/multipliers, and Charpit'snon-linearsolvers.	20	

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2	**Completevs.GeneralIntegral Workbook** A problem-solving assignment assessingtheclearexecutionof usingacompleteintegralalong with an arbitrary function relation to construct a general solution.		10
	Total:	20	10

- **DescriptionofSEE:Formulation&CharpitSolverTest(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(10Marks):**Astructuredproblem-solvinglog trackingthesystematicbridgingofcompleteintegralswith arbitraryfunctionconfigurationstoformulategeneralPDE solutions.

5	**Higher-OrderLinear PDEs& BoundaryValueProblems.**	12	20%

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

SrNo.	EvaluationMethods	SEE	CCE
1	**TechnicalCase Study** An applied engineering report where students model a real-world physical system into a second-order PDE and solve it completelyusingtheseparation of variables method.	20	
2	**Vivavoce**		10
	Total:	20	10

- **Description of SEE: echnical Case Study Report (20 Marks):**Aprofessionalcapstonereportwherestudentsmodel an engineering infrastructure system (e.g., heat conduction or wave propagation) into a second-order PDE and solve it completely

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SuggestedSpecificationtablewithMarks:

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

Course Outcomes:

Afterlearningthe course,thestudents shouldbeable to:	
CO1	Verify functions for analyticity using Cauchy-Riemann equations and construct harmonicconjugatestomapsteady-statephysicalfields(likefluidflowor heat).
CO2	ApplyMöbiusandconformaltransformationstomapcomplexgeometricboundaries, and solve complex contour integrations using the Cauchy Integral Formula.
CO3	Expandcomplex-valuedfunctionsintoTaylorandLaurentseriestoevaluate singularities and approximate system behaviors.
CO4	Formulateandsolvefirst-orderlinearandnon-linearpartialdifferentialequations (PDEs) using Lagrange and Charpit methods to model dynamic surfaces.
CO5	Classifysecond-order linear PDEs andapplythe separation ofvariables method to solveboundaryvalueproblemsrepresentingphysicalphenomena(e.g.,heatequation, wave equation).

InstructionalMethod:

Thecoursewillbedeliveredusingtraditionalclassroomteachingsupportedbyactiveand 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 boundarytransformations,utilizingtextbooksandnotebookstofocusonapplicationover memorization.
- **DiagnosticandAudit-basedpractice**foridentifying"logiccracks"inderivativeproofs and verification profiles through "The Analyticity Audit".
- **Graphicalandvisualmethods**forvisualizingcomplexpowerseriesconvergencelimits, pole singularities, and 3D surface profiles of PDEs.

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- **Active Learning Assignments (ALA)** including rapid conceptual checkpoints for qualitativetheoremsandstructuredproblem-solvingworkbooksfortrackingcomplete versus general integrals.
- **Mini-projectsandengineeringcasestudies**likethe"TechnicalCaseStudyReport"to model and solve real-life physical infrastructure equations using the separation of variables method.
- **Interactiveassessments**through"PracticalPerformanceExams,"screen-sharevideo lectures, and live "Viva Voce" defenses to reinforce conceptual understanding.
- **Internalevaluation**basedonprescribedSEEandCCEcomponents,trackingstudent progress via audit reports, convergence logs, programming files, and oral defenses.

ReferenceBooks:

[1].**AdvancedEngineeringMathematics,** ByErwinKreyszig,WileyIndiaPvt.Ltd. [2].

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

[3].**CalculusandAnalyticGeometrybyG.B.ThomasandR.L.Finney** (Pearson). [4].

Basic Engineering Mathematics by **John Bird** (Elsevier/Newnes)

Suggestive Rubrics:

SuggestiveAssessmentGuidelines:
Module1: **ALA:TheAnalyticityAudit (10 Marks)** • **10Marks:**Alllogicandderivativeerrorssuccessfullydiagnosedandcorrectedusing Cauchy-Riemann equations with professional-grade engineering justifications. • **08Marks:**MosterrorsidentifiedusingCauchy-Riemannequations;correctionsare accurate but justifications are brief. • **05Marks:**Identifiedbasicderivativeerrorsbutstruggledwithcomplexharmonic conjugate reconstruction or multi-variable logic. • **02Marks:**Minimalidentificationoferrors;unabletoprovidecorrectalternativesor apply analyticity conditions. • **00Marks:**Not submitted.

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Module2:

ALA:"PropertyShowdown"Quiz(10Marks)

- **10Marks:**Flawlessqualitativereasoningandperfectconceptualmasterydemonstrated across all short-answer theorem questions.
- **08Marks:**Strongconceptualunderstandingshown;answersareaccuratebutmissing minor theoretical nuances.
- **05 Marks:** Understands standard computational applications but lacks verbal or conceptualprecisionforqualitativetheoremslikeLiouville'sorMaximum-Modulus.
- **02Marks:**Limitedcomprehensionoftheoremconditions;unabletoidentifybasic qualitative properties.
- **00Marks:**Not submitted.

Module3:

- **CCE/ALA:Maclaurin ExpansionShortVideo(10 Marks)**
  - **10Marks:**Highlyprofessional3-minutevideodelivery;flawlessverbalandvisual breakdown of multi-element complex function series expansion.
  - **08Marks:**Successfulvideowalkthrough;seriesexpansionstepsareaccuratebutthe oral explanation lacks fluid transitions.
  - **05Marks:**Calculatedexpansiontermscorrectlyintherecording,buttheexplanation fails to articulate the underlying convergence logic clearly.
  - **02Marks:**Minimaleffortinexplanation;videocontentcontainssignificant mathematical errors during expansion steps.
  - **00Marks:**Not submitted.
- **SEE/ESE:The"TaylorApproximation"SoftwareLab(20Marks)**
  - **20 Marks:** Exceptional technology-assisted logs tracking uniform convergence boundariesandcomputingpolynomialapproximationerrorsdynamicallywithperfect precision.
  - **16Marks:**Accurateuseofsoftwaretogeneratepowerseries;convergencelogsare correct but lack deep error analysis.
  - **10Marks:**GeneratesstandardTaylor/Maclaurin plotsbutfailstoaccuratelytraceor evaluate uniform convergence zones near boundaries.
  - **05Marks:**Poorexecutionofsoftwaretools;visualizationdoesnotmatchthe mathematical limits of the series.
  - **00Marks:**Not submitted.

Module4:

- **CCE/ALA:Completevs.GeneralIntegralWorkbook(10Marks)**
  - **10Marks:**Flawlessworkbooktracking;impeccablepathlogicmappingtheconnection

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between completeintegralsandarbitraryfunctionstogenerate generalPDEsolutions.

- **08Marks:**Correctworkbookformattingandmathematicalstepswithminornotation gaps in dependency tracking.
- **05Marks:** Workbookincludesstandardintegrationsbutlacksaclearlogicalflowwhen constructing the general solution.
- **02Marks:**Poorlystructurednotes:failstocorrectlylinkvariablesoreliminate arbitrary parameters.
- **00Marks:**Not submitted.

- **SEE/ESE:FormulationTest(20Marks)**
  - **20Marks:**FlawlessconstructionofdifferentialsurfacesusingLagrangemultipliersand accurate execution of Charpit's non-linear solver steps.
  - **16Marks:**SuccessfulgenerationofPDEs;auxiliaryequationsaremostlycorrectwith minor computational errors.
  - **10Marks:**FormulatesbasiclinearPDEsfromparametereliminationbutbreaksdown entirely during non-linear Charpit setups.
  - **05Marks:**Significantdifficultyformulatingequations;unabletosetupLagrange grouping parameters accurately.
  - **00Marks:**Not submitted.

Module5:

- **CCE/ ALA:VivaVoce(10 Marks)**
  - **10Marks:**Confidentlivedefense;flawlessuseoftechnicalvocabularytoexplain second-order PDE classifications and initial/boundary values.
  - **08Marks:**Accurateoraldescriptionsofsolutionsteps;minorhesitationwhen explaining physical boundary states.
  - **05Marks:**CanidentifybasicPDEcategoriesbutrequiresconstantpromptingto explain how initial conditions apply to the solution.
  - **02Marks:**Unabletodefinecoreengineeringmathterms;cannotverballyjustify solution steps.
  - **00Marks:**Not submitted.

- **SEE/ESE:TechnicalCaseStudy(20Marks)**
  - **20Marks:**Exceptionalengineeringreport;perfectlymodelsaphysicalsystemintoa second-order PDE and solves it completely via separation of variables.
  - **16Marks:**Mathematicallysoundcasestudy;appliesseparation ofvariablesaccurately but has minor slips calculating final Fourier coefficients.
  - **10Marks:**CorrectlyclassifiesthephysicalPDE(heat/wave)butstrugglestomatch boundary parameters to complete the engineering solution.
  - **05Marks:**Poorsystemmodeling;theselectedsolutiontechniquedoesnotalignwith the given boundary conditions.

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• **00Marks:** Not submitted.

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