Complex Analysis and Probability Distributions

Course Code	1BMATME401	Scheme	2025
Type of Course	Applied Science Course (ASC)	Semester	IV
Teaching Hours/Week (L: T: P)	70 (2:2:0)	CIE Marks	50
Total Hours of Pedagogy per semester CI (L /T):LI(P):SL&TW:	90 (28:28:0:34)	SEE Marks	50
Credits	3	Total Marks	100
Examination type (SEE)	Theory	Exam Hours	03

At the end of the course, the student will be able to:

CO1: Apply concepts of complex analysis, Cauchy-Riemann equations, Milne-Thomson method, and harmonic functions to construct and analyze analytic functions in engineering applications.

CO2: Apply Laplace Transform to solve ODE' S and PDE'S of Engineering Problems.

CO3: Apply probability distributions and joint probability concepts to model and analyze uncertainties encountered in mechanical engineering systems.

CO4: Utilize sampling theory, hypothesis testing, and Markov chain models for statistical inference and stochastic system analysis.

CO5: Analyze engineering reliability and queueing problems using statistical measures, queueing models, and reliability indices for performance evaluation and decision-making.

Module-1: Complex Analysis

Review of function of a complex variable, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms. Construction of analytic functions: Milne-Thomson Method-Problems, Harmonic Functions-Problems.

Number of Hours:**08**

Module-2: Laplace Transforms

Laplace Transform: Definition and Laplace transform of elementary functions (statements only) Problems on Properties: $L[f(at)] = \left(\frac{1}{a}\right)\bar{f}\left(\frac{s}{a}\right)$, $L[e^{at}f(t)] = \bar{f}(s-a)$, $L[t^n f(t)] = (-1)^n \frac{d^n}{ds^n}[\bar{f}(s)$, $L = \left[\frac{f(t)}{t}\right] = \int_s^\infty \bar{f}(s)ds$. Laplace transforms of unit-step function – problems.

Inverse Laplace Transform: Definition and problems on inverse Laplace transforms (without Proof). Solution of linear ordinary differential equations using Laplace transforms.

Number of Hours:**08**

Module-3: Probability Distributions

Review of basic probability theory. Random variables (discrete and continuous), probability mass and density functions. Binomial, Poisson and normal distributions- problems.

Joint Probability Distribution: Joint Probability distribution for two discrete random variables, expectation, covariance and correlation.

Number of Hours:**08**

Module-4: Sampling theory

Sampling theory: Sampling, Sampling distributions, standard error, Type I and Type II errors, Level of significance, confidence limits for means, one tailed and two tailed tests, test of hypothesis (Single mean, Single proportion, difference of means and difference of proportions), student's t-distribution, Chi-square distribution (goodness of fit of poison),

Number of Hours:**08**

Module-5: Markov Chain, Queueing Theory and Reliability Engineering

Stochastic Process: Stochastic processes, probability vector, stochastic matrices, fixed points, regular stochastic matrices, Markov chains, higher transition probability-problems.

Queueing Theory: Problems on Queueing model with M/M/1 (No derivation)
Reliability Engineering: Reliability of systems, Problems on MTTF, MTBF. (No derivations).

Number of Hours:**08**

Suggested Learning Resources: (Textbook/ Reference Book/ Manuals):

Textbooks:

1. S.C.Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand Publishing.
2. R. K, Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, Narosa Publishing House.
3. B.S.Grewal, Higher Engineering Mathematics, Khanna Publishers.

Reference books / Manuals:

1. B.V. Ramana, Higher Engineering Mathematics, Mc Graw-Hill Education,11th Ed., 2017
2. M.R.Spiegel, J. Schiller, and R.A. Srinivasan, Schaum's Outline of Probability and Statistics, McGraw Hill.
3. S. C. Gupta, Statistical Methods, S. Chand Publishing.
4. V. K. Rohatgi and A. K. Md. Ehsanes Saleh , An Introduction to Probability and Statistics, Wiley.

Web links and e-Resources:

- http://academicearth.org/
- VTUe-ShikshanaProgram
- VTUEDUSATProgram
- https://nptel.ac.in/courses/111105160
- https://nptel.ac.in/courses/127106019
- https://ocw.mit.edu/courses/18-335j-introduction-to-numerical-methods-spring-2019/

https://ocw.mit.edu/courses/18-330-introduction-to-numerical-analysis-spring-2012/pages/syllabus/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the delivered lessons shall develop students' theoretical and applied mathematical skills.
2. State the need for Mathematics with Engineering Studies and Provide real-life examples.
3. Support and guide the students for self–study.
4. You will also be responsible for assigning homework, grading assignments and quizzes, and documenting students' progress.
5. Encourage the students to learn groups to improve their creative and analytical skills.
6. Show short-related video lectures in the following ways:
   - As an introduction to new topics (pre-lecture activity).
   - As a revision of topics (post-lecture activity).
   - As additional examples (post-lecture activity).
   - As an additional material of challenging topics (pre-and post-lecture activity).
   - As a model solution of some exercises (post-lecture activity).

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

The CIE Theory component consists of average of TWO IA tests for 25 marks and Continuous Comprehensive Assessments (CCA) for 25 marks.

To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.

To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.

Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE is at least 40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)**shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Assignment (at RBL3 or RBL4 levels) for Team Work	10
2.	GATE-based Aptitude Test	15

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes seminars, micro projects, industrial visits, any other student activities etc.)

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1.	Seminar on Complex Analysis	5
2.	MATLAB/Python Simulation of Laplace-Transform problems	5
3.	Mini Project on statistical Models in Engineering Applications	5
4.	Case Study on Signal Processing using Transform Techniques	5

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):
1. Sample Rubrics - Mini-Project

Criterion	Exemplary (3)	Proficient (2)	Basic (1)	Weight
Problem definition & data	Clear, relevant civil-engineering questions; data source and limitations documented.	Mostly clear; minor gaps in context or data description.	Vague questions or poorly documented data.	10%
Data processing & descriptive statistics	Correct cleaning, visualization, and computation of key measures; patterns clearly highlighted.	Mostly correct; minor computational errors.	Significant errors, missing key measures or plots.	25%
Probabilistic modelling (distributions, inference)	Appropriate distributions and tests used; assumptions stated; results interpreted in context.	Reasonable choice of models; some assumptions implicit; interpretation mostly sound.	Inappropriate or poorly justified models; limited interpretation.	30%
Civil engineering insight / risk framing	Clear link to design/assessment decisions, safety and uncertainty; limitations discussed.	Some discussion of implications; limited treatment of limitations.	Minimal civil engineering interpretation on beyond numbers.	20%
Report & communication	Well-structured report, clear figures/tables, reproducible calculations; effective brief presentation.	Acceptable structure; some clarity issues; presentation adequate.	Disorganized or incomplete report; weak presentation.	15%

Students' activities for TW/SL under NCrF: Samples only

As per National credit formwork (NCrF) students must spend 120 hours of study for 4 credit courses, which include Course instructions (CI-70 hour) and Teamwork/ Self learning (TW/Sl-50 hours). Hence, students must complete minimum of two activities as part of NCrF. These learning activities shall be considered as CCA components of CIE. The evaluation activities will be done using set of rubrics developed for each activity. The following sample activities are listed below. The course coordinator can also give their own TW/SL activities as per the course outcomes.

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).