Syllabus template

Semester: 7	
Programme: Mathematics	
Course: Analysis-6 & Research Methodology	
Paper code: C4MT230742T& C4MT230742P	**Credits:4**
Hours/week: 3 + 2	
Category: Core/MDC/SEC/VAC: Major	
Theory / Practical / Composite: Composite	
No of Modules: Nil	

Course Overview: Analysis-6

This course develops the theory of complex analysis, beginning with the algebraic and geometric structure of complex numbers. It introduces the topology of the complex plane, including connectedness and stereographic projection, providing a foundation for understanding complex functions. The course studies sequences and series of complex numbers, focusing on convergence, Cauchy criteria, and classical tests for series. It then explores elementary functions of a complex variable and establishes key ideas of limits, continuity, and analytic functions, including the role of Cauchy–Riemann equations.

Power series are treated as fundamental tools, with emphasis on radius of convergence, analyticity, and local power series representation of analytic functions. Complex integration is developed through contour integrals, Cauchy's integral theorem, and its major consequences such as Morera's theorem, Liouville's theorem, and the Fundamental Theorem of Algebra, along with singularities and residues.

The course concludes with sequences and series of complex functions, highlighting uniform convergence and its implications for continuity and analyticity. Overall, it builds a rigorous and intuitive understanding of analytic functions and their central role in mathematics and applications.

Research Methodology:

This course introduces the fundamental principles of research methodology with a focus on statistical techniques for data analysis and inference. It begins with descriptive statistics and a review of key probability distributions, followed by concepts of population, sampling methods, and sampling distributions.

The course develops methods of parameter estimation, including maximum likelihood estimation and confidence intervals, and explores relationships between variables through correlation and curve fitting. It also covers hypothesis testing, including tests for means, proportions, and goodness of fit, along with concepts of errors and significance.

Overall, the course equips students with essential tools for analyzing data, drawing inferences, and conducting systematic research in scientific and applied contexts.

Course Outcome: On successful completion of the course a student will be able to do the following:

1. **Explain** the algebraic and geometric structure of complex numbers, including topology of the complex plane and stereographic projection.
2. **Analyze** convergence of sequences and series of complex numbers using Cauchy criteria and standard convergence tests.
3. **Apply** concepts of limits, continuity, and elementary complex functions, and examine their properties in relation to connectedness and compactness.
4. **Examine** differentiability and analyticity of complex functions using Cauchy–Riemann equations and related conditions.
5. **Develop and analyze** power series representations of analytic functions, including determination of radius of convergence and uniform convergence properties.
6. **Apply** contour integration techniques and major results such as Cauchy's integral theorem, Liouville's theorem, and residue theory to solve problems.
7. **Analyze** sequences and series of complex functions, emphasizing uniform convergence and its implications for continuity and analyticity.
8. **Explain** concepts of descriptive statistics, including measures of central tendency and dispersion, and interpret graphical representations of data.
9. **Apply** probability distributions (Binomial, Poisson, Normal, Chi-square, t, F) to model data and solve statistical problems.
10. **Analyze** sampling methods and sampling distributions, and compute standard errors for statistical estimates.
11. **Estimate** population parameters using point and interval estimation methods, including maximum likelihood estimation and confidence intervals.
12. **Analyze** relationships between variables using correlation and regression techniques, including curve fitting and goodness of fit.
13. **Formulate and test** statistical hypotheses using appropriate tests, and interpret results considering Type I and Type II errors and significance levels.

Prerequisites:

SYLLABUS: C4MT230742T

UNIT/Module	CONTENT	NUMBER OF CLASSES	CO Mapping	COGNITIVE LEVEL
I.	Field structure of complex	**9 classes**	**CO1, CO2**	**K2, K3, K4**

	numbers, field of complex numbers cannot be totally ordered, Geometric Interpretation of complex numbers, Topology of the complex plane: staircase connected and connected sets in Argand plane. Stereographic Projection **(5)**. Sequence of complex numbers: Convergence. $\{z_n\}_n$ is convergent iff $\{Re\ z_n\}_n$ and $\{Im z_n\}_n$ both are convergent. Cauchy Condition for convergence. Subsequence in C: every bounded sequence has a convergent subsequence**.** Series of complex numbers: Conditional and absolute convergence. Statement of (i) Ratio-test, (ii) Root-test Dirichlet's test (iv) Abel's test and their applications **(4).**			
II.	Function of a complex variable – Exponential, Logarithmic, Direct and Inverse Circular and Hyperbolic functions. Concepts of limit and continuity, sequential continuity is equivalent to continuity. Continuous image of a connected (compact) set is connected (compact respectively) (**4)** Analytic Function: Differentiability – definition, derivability implies continuity, differentiability of sum, difference, product, quotients	**16 classes**	**CO3, CO4, CO5**	**K3, K4**

	and composition of differentiable functions, Cauchy – Riemann equations are necessary but not sufficient conditions for differentiability of a function at a point in its domain of definition, sufficient conditions for differentiability. Definition of analytic and entire function **(5)**. Power Series as an analytic function: Radius of convergence of a power-series (Cauchy-Hadamard Form and Ratio Form) Absolute and uniform convergence of a power series strictly within the circle of convergence, a power series and its derived power series have same radius of convergence. A power series is an analytic function strictly within its circle of convergence and conversely if f is analytic in a domain D, then f can be represented by a power-series locally about each point z_0 in D. **(7)**			
III.	Integration of complex functions along a curve, Cauchy's integral theorem and it's applications: Morera's theorem, Lioville's theorem, singularities, removable singularity, pole and essential. Residues, contour integrations. Fundamental theorem of Classical Algebra **[10]**. Sequence of functions and series of functions in C: Pointwise and uniform convergence.	**14 classes**	**CO6, CO7**	**K3, K4, K5**

	Cauchy Criterion M-Test (statement only). Continuity, analyticity of limit function/sum function in case of uniformly convergent sequence/series of function in C **[4].**			
Syllabus: C4MT230742P				
I.	[Descriptive Statistics: [For self-study]. Sample Characteristics: Idea of Discrete and Continuous Data, Frequency distribution, Histogram, Ogive etc. Measures of central tendency: Mean, Median Mode, Quartile, percentile etc. Measures of Dispersion: mean deviation, Standard deviation etc. Absolute and Relative Dispersion: coefficient of variation etc.] Recapitulation: Binomial, Poisson, Normal, Chi-Square, t and F Distribution and some basic properties of them **[2].** Idea of Population and Sample, Distribution of Sample and Sampling distribution, Idea of different types of Sampling: SRSWR, SRSWOR, Computation of Standard error. Sampling Distribution of some statistics **[6].**	**8 classes**	**CO8, CO9 CO10**	**K2, K3, K4**
II.	Estimation: Point estimation: Consistent and unbiased estimate. Use Maximum Likelihood estimate for estimation of parameters from different distributions. Interval Estimation: Outline of method for interval estimation. Confidence interval for $m,\sigma\ of\ N(m,\sigma) population.$ Confidence interval for $p\ and\ \mu\ of\ B(N,p) and\ P(\mu)$ population respectively **[6].** Bivariate Samples: Corelation coefficient and curve fitting (linear	**10 classes**	**CO11, CO12**	**K3, K4**

	and non-linear) by least square method. Idea of goodness of fit **[4].**			
III.	Testing of Hypothesis: Null Hypothesis and Alternate Hypothesis. Critical Region and Type-I, Type-II error, Power of a test significance level and best Critical region. 1.Test for $m,\sigma\ of\ N(m,\sigma) population.$ 2.Test for comparison of means of two Normal population. 3.Test for $p\ of\ B(N,p) population.$ 4.Test for comparison of two binomial population. 5.χ^2 test for goodness of fit of a population.	**8 classes**	**CO13**	**K3, K5**
Text Books				
1. Complex Analysis and Applications: Brown and Churchill.				
2. Foundations of Complex Analysis :S. Ponnuswammy.				
3. Functions of one complex variable: Conway.				
4. Groundwork of Mathematical Probability and Statistics: Amritava Gupta.				
5. Fundamentals of Statistics (Vol-1): Goon, Gupta & Dasgupta.				
6. Fundamentals of Statistics (Vol-2): Goon, Gupta & Dasgupta.				
Suggested readings				
1. Complex Analysis: Lars. V. Alfohrs				
2. Complex Analysis A short course: Thumban Nair				
3. Outline (Vol-1): Goon, Gupta & Dasgupta				
4. Outline (Vol-2): Goon, Gupta & Dasgupta				
Web Resources				
Evaluation: Theory (C4MT230742T) CIA: **7+3=10**; **End-Semester Exam**: **50** **Practical (C4MT230742P): Continuous Assessment:** (**38+2**)				
Paper Structure for Theory Semester Exam: 5 questions each of **10** marks out of a set of **9** questions.				

Course outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	Explain the algebraic and geometric structure of complex numbers, including topology of the complex plane and stereographic projection.	**K2**
CO2	Analyze convergence of sequences and series of complex numbers using Cauchy criteria and standard convergence tests.	**K3, K4**
CO3	Apply concepts of limits, continuity, and elementary complex functions, and examine their properties in relation to connectedness and compactness.	**K3, K4**
CO4	Examine differentiability and analyticity of complex functions using Cauchy–Riemann equations and related conditions.	**K4**
CO5	Develop and analyze power series representations of analytic functions, including determination of radius of convergence and uniform convergence properties.	**K3, K4**
CO6	Apply contour integration techniques and major results such as Cauchy's integral theorem, Liouville's theorem, and residue theory to solve problems.	**K3, K5**
CO7	Analyze sequences and series of complex functions, emphasizing uniform convergence and its implications for continuity and analyticity.	**K4, K5**
CO8	Explain concepts of descriptive statistics, including measures of central tendency and dispersion, and interpret graphical representations of data.	**K2**
CO9	Apply probability distributions (Binomial, Poisson, Normal, Chi-square, t, F) to model data and solve statistical problems.	**K3**
CO10	Analyze sampling methods and sampling distributions, and compute standard errors for statistical estimates.	**K3, K4**
CO11	Estimate population parameters using point and interval estimation methods, including maximum likelihood estimation and confidence intervals.	**K3, K4**
CO12	Analyze relationships between variables using correlation and regression techniques, including curve fitting and goodness of fit.	**K4**

CO13	Formulate and test statistical hypotheses using appropriate tests, and interpret results considering Type I and Type II errors and significance levels.	**K3, K5**