COURSE DESCRIPTION FORM: MT-1003 Calculus and Analytical Geometry

INSTITUTION FAST School of Computing, National University of Computer and Emerging Sciences, Islamabad

PROGRAM TO BE EVALUATED BS-CS – **Fall 2025**

Course Description

Course Code	MT-1003
Course Title	Calculus and Analytical Geometry
Credit Hours	3
Course Instructors	Dr. Hamda Khan, Mr. Tajammul Hussain, Mr. Sajid Khan
Prerequisites by Course(s) and Topics	-
Grading Policy	Absolute Grading
Policy about missed and late assessment items in the course	Retake of missed assessment items (other than sessional / final exam) will not be held. A student who misses an assessment item (other than sessional / final exam) is awarded zero marks in that assessment item, i.e., late submission will not be accepted. For the missed sessional / final exam, exam retake/ pre-take application along with necessary evidence are required to be submitted to the department secretary. The examination assessment and retake committee will decide the exam retake/ pre-take cases.
Course Plagiarism Policy	Plagiarism in projects or midterm/ final exam may result in an F grade in the course. Plagiarism in an assessment item will result in zero marks in the respective assessment category. The case will be forwarded to the disciplinary committee as well.
Assessment Instruments with Weights (homework, quizzes, midterms, final, programming assignments, lab work, etc.)	**100% Theory** Assessment items

Assessment Item	Number	Weight (%)
Assignments	4-6	5-8
Quiz	5-7	8-10
Sessional I	1	15
Sessional II	1	15
Project	1	07
Final Exam	1	45-50

Course Coordinator	Dr. Hamda Khan
URL (if any)	-
Current Catalog Description	Topics including Function, Limits, Continuity, Curve Sketching, Derivatives, Chain Rule, Application of differentiation, Extreme values, Integration, Techniques of integration, Applications of integration, Transcendental Functions, L'Hôpital's rule, Inverse trigonometric functions, Sequence, Series (infinite series, geometric series), Divergence and convergence test for series will be covered in the course.

Textbook	**Thomas' Calculus, Early Transcendentals 13th ed.,** by George B. Thomas Jr, Maurice D. Weir and Joel Hass, Pearson.			
Reference Material	1. Calculus with analytic geometry by Earl W. Swokowski, Alternate edition, Prindle, Weber & Schmidt. 2. Calculus Early Transcendentals, 8th ed., by James Stewart, Cengage Learning.			
Course Goals	**A. Course Learning Outcomes (CLOs) (Cognitive Level) (PLO Mapping)**			
	After completion of the course, the students shall be able to: 1. Apply knowledge of mathematics, science and appropriate knowledge domain to mathematically model and conceptualize defined problems. (2)(3) 2. Use fundamental principles of mathematics and relevant domains to identify, analyze and solve problems in order to reach substantiated conclusions. (4)(3)			
	B. Program Learning Outcomes (Covered attribute is indicated with a tick (✔) mark)			
	PLO 1	Academic Education	Completion of an accredited program of study designed to prepare graduates as computing professionals	
	PLO 2	Knowledge for Solving Computing Problems	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the abstraction and conceptualization of computing models from defined problems and requirements	
	PLO 3	Problem Analysis	Identify, formulate, research literature, and solve complex computing problems reaching substantiated conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines	✔
	PLO 4	Design/ Development of Solutions	Design and evaluate solutions for complex computing problems, and design and evaluate systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations	
	PLO 5	Modern Tool Usage	Create, select, adapt and apply appropriate techniques, resources, and modern computing tools to complex computing activities, with an understanding of the limitations	
	PLO 6	Individual and Team Work	Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings	

	PLO 7	Communication	Communicate effectively with the computing community and with society at large about complex computing activities by being able to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions	
	PLO 8	Computing Professionalism and Society	Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice	
	PLO 9	Ethics	Understand and commit to professional ethics, responsibilities, and norms of professional computing practice	
	PLO 10	Life-long Learning	Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional	

C. Mapping of CLOs on PLOs

CLO \ PLO	1	2	3	4	5	6	7	8	9	10
1			**C2**							
2			**C4**							

Topics covered in the course	**Topics**	**No. of Weeks**	**Contact Hours**	**CLOs**
	• Properties of real numbers, functions, domain and range of functions, problem formulation, sketching of functions (trigonometric, logarithmic, inverse and exponential) Use of modern tools / technology: sketching	1.5	4.5	1
	• Limits of function, calculating limits using limit laws, one sided limit, two-sided limit, continuity. Use of modern tools / technology: finding limits	1.5	4.5	1
	• Limits at Infinity; Horizontal and vertical Asymptotes and sketching of asymptotes. Use of modern tools / technology: check behaviour of a function at infinity	0.5	1.5	2
	• Derivatives; slopes, tangents, derivative at a point, derivatives of function, differentiation rules. Use of modern tools / technology: using technology to solve problems involving derivatives	1	3	1
	• Derivatives as rate of change. Use of modern tools / technology: using technology to solve problems involving derivatives	0.5	1.5	2
	• Derivative of trigonometric functions, chain rule, implicit differentiation, derivative of inverse logarithmic and inverse trigonometric functions.	1.5	4.5	1
	• More on application of differentiation; related rates, linearization and differentials. Use of modern tools / technology: using technology to solve problems involving derivatives.	1	3	2

	• Extreme values of functions, increasing/decreasing functions, derivative tests, local minimum/maximum, concavity, L'Hôpital's rule.	0.5	1.5	1
	• Curve sketching, modeling of problem, procedure of applied optimization	1.5	4.5	2
	• Antiderivatives; problem formulation, initial value problem solution. Use of modern tools / technology: solution of initial value problem	0.5	1.5	2
	• Definite integrals, fundamental theorem of Calculus, substitution method for indefinite and definite integrals.	1	3	1
	• Area between curves. Use of modern tools / technology: using technology to calculate integrals.	1	3	1
	• Integration by parts, trigonometric integrals, trigonometric substitution, improper integrals	1.5	4.5	1
	• Sequences, infinite series, geometric series, partial sum, nth-term test. Use of modern tools / technology: programming to check convergence or divergence	1.5	4.5	2
	Total	**15**	**45**	

Programming Language for Assignments	Python (Sympy, Scipy, Numpy)			
Class Time Spent (in hours – per week)	**Theory (%)**	**Problem Analysis (%)**	**Solution Design (%)**	**Social and Ethical Issues (%)**
	35	30	30	5
Oral and Written Communications	Every student is required to submit _01___ written report of typically _10_ pages.			

COURSE CONTENTS

Weeks	Contents/Topics	Courseware Events (Lab/ Case Study/ Quiz/ Assignment/ Project/ Presentation/ Research Report/ Term Paper etc.)	Comments (if any)
1	Introduction to calculus, importance of calculus in computing. Functions, domain-range, problem formulation. Even-odd functions, symmetry, common graphs, exercise 1.1. Combining functions, composition, translation.		
2	Scaling, sketching of functions (trig, log, exponential, inverse) exercise 1.2. Discussion on important functions for algorithm analysis. Definition of limit, left-hand right-hand limits, examples. Exercise 2.2.	Quiz # 1	
3	One-sided limits, exercise 2.4. Continuity, exercise 2.5. Limits involving infinity, asymptotes of graphs.	Assignment # 1	
4	Exercise 2.6. Use of limits in asymptotic analysis, slopes, tangents, derivative. Derivative at point, by definition, exercise 3.1. Use of derivates, slopes & tangents in machine learning and signal processing. Derivatives of function, exercise 3.2, differentiation rules, exercise 3.3.	Quiz # 2	
5	Derivatives as rate of change, exercise 3.4. Derivatives of trigonometric functions, exercise 3.5.	Quiz # 3 Assignment # 2 Sessional I	
6	Chain rule; examples, exercise 3.6. Implicit differentiation; examples of real-life scenarios, exercise 3.7. Derivatives of inverse, logarithmic and inverse trigonometric functions, exercise 3.8, exercise 3.9.	Sessional I	
7	Related rates, problem formulation, examples, exercise 3.10. Familiarization with advanced applications of differentiation in scenarios that use regression (weather forecasting and price prediction). Linearization, exercise 3.11.	Quiz # 4	
8	Extreme values of functions, examples, exercise 4.1. First derivative test, increasing decreasing functions, local minima, local maxima, examples and exercise 4.3, theorems. Concavity, examples. Curve sketching.	Assignment # 3	

9	Exercise 4.4. L'Hôpital's rule, examples, exercise 4.5. Procedure of applied optimization, modeling of problem, examples.		
10	Exercise 4.6. Introduction to gradient descent and its applications. Antiderivatives, examples, exercise 4.8. The definite integral.	Assignment # 4 Quiz # 5	
11	Exercise 5.3. Fundamental theorem of calculus, exercise 5.4. Substitution method for indefinite integral, exercise 5.5.	Sessional II	
12	Substitution method for definite integral, area between curves, examples, exercise 5.6, exercise 8.1. Applications of integrals in computer science (computer games, terrain modeling, dealing with nondeterminism and uncertainty).	Sessional II **Project**	
13	Integration by parts, trigonometric integrals, exercise 8.2, exercise 8.3. Trigonometric substitution, exercise 8.4.	Quiz # 6	
14	Integration of rational functions by partial fractions, exercise 8.5. Improper integrals, examples, exercise 8.8. Sequences, exercise 10.1.	Quiz # 7 Assignment # 5	
15	Infinite series, geometric series, partial sum, divergence test, exercise 10.2. Analyzing an algorithm with recursion. Revision.		


Multiple Choice Test
Short Answer Test
Fill in the Blank Test
Matching Test
Labeling
Presentation
Illustrations
Visualizations
Lectures
Analogies
Examples
Articles
Action Plans
Case Studies
Creative Exercies
Code Programs
Construct Simulations
Develop Plans
Experiment
Games
Formulate Standards
Hypothesis
Invention Machines
Problems Projects
Sets of Rules
Songs
Diagram
Story
Written Report
Speech
Outline
Matching Test
Model
Photograph
Diagram
Multiple Choice Test
Discussion Board
Presentation
Summary
Statement
Short Answer Test
Comparison
Oral Report
Analogy
Cite
Collect
Count
Clarify
Define
Examine
Enumerate
Find
Identify
Label
List
Memorize
Recall
Recognize
Show
State
Arrange
Assemble
Combine
Compose
Create
Construct
Design
Develop
Describe
Explain
Formulate
Generalize
Integrate
Invent
Make
Manage
Modify
Modify
Organize
Plan
Prepare
Rearrange
Rewrite
Set-Up
Substitute
Ask
Associate
Cite
Classify
Compare
Describe
Discuss
Exemplify
Interpret
Recall
Report
Select
Summarize
State
Tell
REMEMBER
Level 1
CREATE
Level 6
UNDERSTAND
Level 2
Appraise
Assess
Argue
Choose
Compare
Critique
Conclude
Convince
Decide
Discriminate
Defend
Estimate
Evaluate
Explain
Grade
Interpret
Judge
Justify
Measure
Predict
Prioritize
Prove
Rank
Recommend
Rate
Select
Support
Summarize
Test
Value
Appraisals
Case Studies
Critiques
Court Trials
Projects
Self-Evaluations
Simulations
Surveys
Compare/Establish Standards
Writing Conclusions
Valuing
EVALUATE
Level 5
ANALYZE
Level 4
APPLY
Level 3
Administer
Apply
Calculate
Choose
Demonstrate
Examine
Execute
Experiment
Illustrate
Implement
Instruct
Interpret
Modify
Operate
Prepare
Solve
Sketch
Use
Diagram
Building
Creation
Drama
Illustration
Roleplay
Project
Sketch
Simulation
Sculpture
Q&A
Map
Prototype
List
Demonstration
Painting
Poetry
Analyze
Appraise
Arrange
Calculate
Categorize
Classify
Compare
Contrast
Connect
Criticize
Diagram
Deconstruct
Differentiate
Discriminate
Divide
Examine
Explain
Experiment
Infer
Order
Organize
Outline
Question
Select
Separate
Survey
Problem Exercises
Case Studies
Discussion
Debug
Graphs
Syllogism Breakdown
Questionnaire
Argument
Critical Incidents
Propaganda