National University
of Computer & Emerging Sciences
Islamabad

MT1003 - Calculus and Analytical Geometry

Assignment No: 03
Section: CS (All Sections)
Due date: 23 October, 2025 (morning)

Individual Assignment
Semester: Fall 2025
Marks: 120

Instructions:

1. Plagiarized work will result in zero marks.
2. No retake or late submission will be accepted.
3. Attach complete code, results, and screenshot for questions that require programming solution. Programs/codes should be typed.
4. **The complete assignment is to be submitted in soft copy as well as in hard copy. Submit the hardcopy before the deadline through CR, and softcopy on GCR.**
5. The softcopy should be a single PDF file of your complete assignment including programming and non-programming questions.
6. The PDF file should be according to the following format: id_section_A1 e.g., i25-123456_A_A1. A1 in the end denotes Assignment 1. **The title page must include complete student information, including name, section, id, course name, and assignment number.**
7. The images of by-hand solution should be properly scanned. You can use any mobile application such as CamScanner or Adobe Scan for scanning. Each of these applications allow you to export pdf or image files which you can use to combine with your programming solutions. Do not attach direct images from the camera application of your mobile phone, or screenshots.
8. Python is the only approved programming language.

Assignment CLO

CLO 2: Use fundamental principles of mathematics and relevant domains to identify, analyze and solve problems in order to reach substantiated conclusions.

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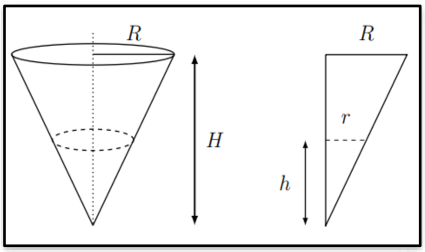
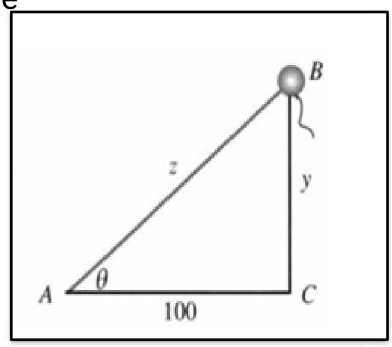
Question 1

Water is leaking at a constant rate out of a conical cup of height H and radius R. Find the rate of change of the height of water in the cup at the instant that the cup is full, if the volume is decreasing at a constant rate k.



Question 2

An observer at point A is watching balloon B as it rises from point C. The balloon is rising at a constant rate of 3 meters per second and the observer is 100 meters from point C.



a) Find the rate of change in z at the instant when y = 50.

b) Find the rate of change in the area of right triangle BCA when y = 50.

c) Find the rate of change in θ when y = 50.

Question 3

At the beginning of 2010, a landfill contained 1400 tons of solid waste. The increasing function Wmodels the total amount of solid waste stored at the landfill. Planners estimate that Wwill satisfy the differential equation $\frac{dW}{dt} = \frac{1}{25}(W - 300)$ for the next 20 years. Wis measured in tons, and tis measured in years from the start of 2010.

Use the line tangent to the graph of Wat t = 0 to approximate the amount of solid waste that the landfill contains at the end of the first 3 months of 2010 (that is, at time $t = \frac{1}{4}$).

Question 4

A cylinder with a height of 5 ft and a base radius of 10 in is filled with water. The water is being drained out at a rate of 3 cubic inches per minute. How fast is the water level decreasing?

Question 5

Use the inverse function theorem to find the derivative of following functions:

a. $g(x) = \left(\frac{x+2}{x}\right)$, find $(g^{-1})'(b)$
b. $f(x) = e^{2x} + 3$, find $(f^{-1})'(7)$
c. $h(x) = \ln\ (x + 4)$, find $(h^{-1})'(0)$
d. $f(x) = \sin\ (x), \left[\frac{-\pi}{2}, \frac{\pi}{2}\right]$, find $(f^{-1})'(\frac{\sqrt{3}}{2})$
e. $f(x) = \tan(x), \left(\frac{-\pi}{2}, \frac{\pi}{2}\right)$, find $(f^{-1})'(1)$

Question 6

A balloon expands in the shape of a perfect sphere as air is pumped into it. If the radius is 3 inches before an additional π inches of air is pumped in, use linearization to approximate how much the radius of the balloon increases.

Question 7

The water level, measured in feet above mean sea level, of Lake Lanier in Georgia, USA, during 2012 can be modeled by the function

$$L(t) = 0.01441t^3 - 0.4177t^2 + 2.703t + 1060.1$$

where t is measured in months since January 1, 2012. Esti mate when the water level was highest during 2012.

Question 8

A wire four feet long is cut in two pieces. One piece forms a circle of radius r, the other forms a square of side x: Choose r to minimize the sum of their areas. Then choose r to maximize.

Question 9

Consider the function

$$f(x) = x^3 - 6x^2 + 9x + 1.$$

1. Find its relative maxima and minima using derivatives.
2. Confirm your results using Python's symbolic differentiation.
3. Sketch the graph to show increasing/decreasing behavior.

Question 10

Use Python to find the Linearization of the following function:

$$f(x) = \frac{1}{1+e^{-x}}$$

at $x = 0$. Then, use any AI tool of your choice to solve the same problem. Compare your Python result with the AI-generated solution.

Question 11

A robot uses a distance sensor whose reading follows

$$s = \sqrt{4+t}$$

where tis the time in seconds.

Find the approximate change in distance ds when tincreases from 5 to 5.1 seconds using differentials.
Then, verify numerically using AI tool.

Question 12

Using Python and AI Tools to **Solve a Problem 11**.

You are required to solve the given problem using two different approaches and compare the results.

Note: Include the AI response snippets along with python scripts in assignment submission.