National University
of Computer & Emerging Sciences
Islamabad

MT1003 – Calculus and Analytical Geometry

Assignment No: 04 **Individual Assignment**

Section: CS (all sections) **Semester:** Fall 25

Date: 30-10-2025 10:00am **Marks:** 100

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_A4 e.g., i25-123456_A_A4. A4 in the end denotes Assignment 4. **The title page must include complete student information, including name, section, id, course name, and assignment number.**
7. The images of the 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 allows 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.

Question 1:

An animation director enters the position $f(t)$ of a character's head after t frames of the movie as given in the table below. If the computer software uses interpolation to determine the intermediate positions, determine the position of the head at the frame numbers (a) 208 and (b) 232.

t	200	220	240
$f(t)$	128	142	136

Question 2:

(a) Use differentials to approximate the volume of material needed to manufacture a hollow sphere if its inner radius is 2 m and its outer radius is 2.1 m.

(b) Is the approximation overestimating or understanding the volume of material needed?

(c) Discuss the importance of knowing the answer to (b) if the manufacturer receives an order for 10,000 units.

Question 3:

A revolving light, located 5 km from a straight shoreline, turns at a constant angular speed of 3rad/min. With what speed is the spot of light moving along the shore when the beam makes an angle of 60^0 with the shoreline?

Question 4:

An elevator in a building is located on the fifth floor, which is 25m above ground. A delivery truck is positioned directly beneath the elevator at street level. If simultaneously, the elevator goes down at a speed of 5m/s and the truck pulls away at a speed of 8m/s, how fast will the elevator and the truck be separating 1s later? Assume the speeds remain constant at all times.

Question 5:

A town hangs strings of holiday lights across the road between utility poles. Each set of poles is 12m apart. The strings hang in catenaries modeled by y with the poles at closed interval $[-6, 6]$. What is the height of the string of lights at its lowest point?

$$y = 15\, cosh\left(\frac{x}{15}\right) - 10$$

Question 6:

A variation of the von Liebig model states that the yield $f(x)$ of a plant, measured in the bushels, responds to the amount x of potassium in a fertilizer according to the square root model:

$$f(x) = -0.057 - 0.417x + 0.852\sqrt{x}$$

For what amounts of potassium will the yield increase? For what amounts of potassium will the yield decrease?

Question 7:

Unit monthly sales R of a new product over a period of time are expected to follow the logistic function:

$$R = R(t) = \frac{20{,}000}{1 + 50e^{-t}} - \frac{20{,}000}{51} \quad ; \quad t \geq 0$$

where t is measured in months.

(a) When are the monthly sales increasing? When are they decreasing?

(b) Find the rate of change of sales.

(c) When is the rate of change of sales R increasing? When is it decreasing?

(d) When is the rate of change of sales maximum?

(e) Find any inflection points of R.

(f) Interpret the result found in (e) in the context of the problem.

(g) Using Python, sketch the graph of $R(t)$.

Question 8:

Draw the graph of the functions given below first by hand and then by Python**.** Compare your results and comment.

a) $f(x) = 4x^{\frac{1}{3}} - x^{\frac{4}{3}}$

b) $f(x) = \frac{x^2}{x^2-4}$

Question 9:

Find the limits of the following functions:

a) $\lim_{x\to+\infty} \frac{x^{-\frac{4}{3}}}{\sin\frac{1}{x}}$

b) $\lim_{x\to+0^+} \frac{\ln x}{cosecx}$

c) $\lim_{x\to\frac{\pi}{4}} (1-\tan x)sec2x$

Question 10:

A student writes a Python script to predict CPU temperature $T(t)$ over time (in seconds):

$$T(t) = 50 + 20sin(0.1t)$$

During a test run, they need a quick estimate of the CPU temperature at $t = 32$ seconds but the monitoring system only shows readings every 10 seconds.

a) Find the linear approximation $L(t)$ of $T(t)$ near $t = 30$.

b) Use $L(t)$ to estimate $T(32)$.

c) Use Python:

- To plot both $T(t)$ and $L(t)$ on the same graph between $t = 20$ and $t = 40$.
- Compare visually how accurate the linear approximation is near $t = 30$.

d) Use ChatGPT or any AI tool to generate one new but similar real-world scenario where *linearization could be applied in computing or technology* (for example: predicting battery percentage, network latency, or cooling fan speed).

- Write the new function or situation that the AI suggested.
- Using your own understanding, apply linearization to estimate a value in your new scenario.