



MT1003 - Calculus and Analytical Geometry

Assignment No: 02

Section: CS (All Sections)

Due date: 13th October, 2025

Individual Assignment

Semester: Fall 2025

Marks: 130

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.



Question 1

The displacement (in feet) of a particle moving in a straight line is given by $s = \frac{1}{2}t^2 - 6t + 23$, where t is measured in seconds.

- Find the average velocity over $[8, 10]$.
- Find the instantaneous velocity at $t=8$,
- Draw the graph s as function of t , then draw the tangent line whose slope is the instantaneous velocity in part (b).

Question 2

The cost (in dollars) of producing x units of a certain commodity is $C(x) = 5000 + 10x + 0.05x^2$.

- Find the average rate of change of C with respect to x when the production level is changed from $x = 100$ to $x = 105$.
- Find the marginal cost function.
- Use the marginal cost at $x = 100$ to estimate the cost of producing the 101st item. Then, compare this estimated cost with the actual cost of producing the 101st item. Interpret the results.

Question 3

Find the points on the curve $y = x^3 + 3x^2 - 9x + 10$ where the tangent is horizontal.

Question 4

At what numbers are the following function g differentiable?

$$g(x) = \begin{cases} 2x & \text{if } x \leq 0 \\ 2x - x^2 & \text{if } 0 < x < 2 \\ 2 - x & \text{if } x \geq 2 \end{cases}$$

Give a formula for g' and sketch the graph of g and g' .

Question 5

Find the first and second derivatives of the following functions:

- $p = \left(\frac{q^2+3}{12q}\right)\left(\frac{q^4-1}{q^3}\right)$
- $r = (1 + \sec \theta) \sin \theta$
- $y = \frac{1}{9} \cot(3x - 1)$
- $xy + y^2 = 1$ at $(0, -1)$

Question 6

If a rock is thrown upward on the planet Mars with a velocity of 10m/s, its height (in meters) after t seconds is given by $H(t) = 10t - 1.86t^2$.

- Find the velocity of the rock after one second.
- When will the rock hit the surface?
- At what velocity will the rock hit the surface?



Question 7

The average blood alcohol concentration (BAC) of eight male subjects was measured after consumption of 15 mL of ethanol. The resulting data were modelled by the concentration function

$$C(t) = 0.00225te^{-0.0467t}$$

Where t is measured in minutes after consumption and C is measured in g/dL.

- How rapidly was the BAC increasing after 10 minutes?
- How rapidly was it decreasing half an hour later?

Question 8

Find $f'(x)$ if it is known that

$$\frac{d}{dx}[f(2x)] = x^2$$

Question 9

The following Python code is given to you for calculating the derivative of a function:

```
import sympy as sp
# Define the variable
x = sp.symbols('x')
# Define the function
f = sp.sin((x**2 + 1)**3)
# Compute the derivative
df_dx = sp.diff(f, x)
# Display the function and its derivative
print("Function: f(x) =", f)
print("Derivative: f'(x) =", df_dx)
# Evaluate derivative at a specific point, e.g., x = 1
value_at_1 = df_dx.subs(x, 1)
print("Derivative at x=1:", value_at_1)
```

Using the above python code to calculate the first, second, third and fourth derivative of the given function:

$$f(x) = 4e^{2x} - \sin(3x) + 5x^3 - \ln(2x)$$

Question 10

Use Python to find the derivative of the following function:

$$f(t) = \frac{\sqrt{t}(3t + t^5 - 10) + (t^3 - e^t)}{t^2}$$

Then, use any AI tool of your choice to solve the same problem. Compare your Python result with the AI-generated solution, identify any discrepancies, and discuss possible reasons for the differences (if any).



Question 11

In image processing, suppose an image transformation is modelled as a composition of functions:

$$I(x) = \sin((x^2 + 1)^3)$$

Use the chain rule to compute $\frac{dI}{dx}$.

Question 12

Using any AI tool of your choice, give Question 10 to the tool and ask it to generate two new but similar problems that apply derivatives in algorithms, network traffic analysis, or robotics motion. Ask the AI tool to solve the two problems it generated.

Question 13

Independently solve the two AI-generated problems in **Question 12** using Python. Compare your Python solutions with the AI-generated solutions. Note differences (if any) and discuss/correct mistakes.

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