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CPA

Quantitative Analysis

April 2026

Level: Foundation Level

Question 1a

□ Mathematical Techniques

(a) Explain the following terms as used in the quantitative analysis:

- (i) Function.
- (ii) Domain of a function.
- (iii) Matrix.
- (iv) Differentiation.



✓ Answer for Question 1a

(i) Function

A **function** is a mathematical rule or relationship that maps each input from a given set to exactly one unique output. In quantitative analysis, functions are used to express how one variable (the dependent variable) changes in response to another (the independent variable).

- **Example:** A total cost function can be expressed as $C(x) = 10x + 500$, where x represents the number of units produced, $10x$ is the variable cost per unit, and 500 is the fixed cost.

(ii) Domain of a Function

The **domain** is the complete set of all possible, valid input values (usually represented by x) for which the function is defined and produces a real, meaningful output.

- **In Quantitative Contexts:** While mathematically a domain can be infinite, in business and economics, it is often restricted by real-world constraints (known as the *practical domain*). For instance, in the cost function $C(x)$, the domain is typically $x \geq 0$ because you cannot produce a negative number of items.

(iii) Matrix

A **matrix** (plural: *matrices*) is a rectangular array of numbers, symbols, or expressions arranged in rows and columns. It is used as a powerful tool to store, organize, and manipulate large structures of linear data simultaneously.

- **Application:** In quantitative techniques, matrices are heavily used in **Markov Analysis** (to predict market share shifts), **Linear Programming**, and solving simultaneous equations for resource allocation.
- **Visual Representation:**

$$A = \begin{bmatrix} 10 & 20 \\ 15 & 30 \end{bmatrix}$$

(Where rows might represent different products and columns represent raw materials required).



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Question 2a

□ Mathematical Techniques - Calculus



A manufacturing company produces a commodity whose total cost function (in Shillings “000”) is given by:

$$C(x) = 2x^3 - 15x^2 + 36x + 50$$

Where x represents the number of units produced (in hundreds).

Required:

- (i) Determine the marginal cost function.
- (ii) Calculate the level of output at which the marginal cost is minimised.
- (iii) Determine the minimum marginal cost.
- (iv) Interpret your results in (a) (ii) and (iii) above in the context of production efficiency.

✓ Answer for Question 2a

(i) Determine the marginal cost function

Marginal Cost (MC) is the first derivative of the Total Cost ($C(x)$) function with respect to the output level x .

Given:

$$C(x) = 2x^3 - 15x^2 + 36x + 50$$

Differentiating $C(x)$ with respect to x :

$$MC = \frac{dC}{dx} = (3 \times 2)x^{3-1} - (2 \times 15)x^{2-1} + 36$$

$$MC = 6x^2 - 30x + 36$$

(ii) Calculate the level of output at which the marginal cost is minimized

To minimize the marginal cost function, we find its first derivative with respect to x (which is the second derivative of total cost, or $C''(x)$), set it equal to zero, and solve for x .

Step 1: Find the first derivative of MC

$$\frac{d(MC)}{dx} = 12x - 30$$

Step 2: Set the derivative to zero

$$12x - 30 = 0$$

$$12x = 30$$

$$x = \frac{30}{12} = 2.5$$



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Quantitative Analysis

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Question 1b

□ Probability

The probability of an investor achieving the target profit in a given financial period is 0.12.

Required:

Assuming that the investor makes eight investment trials, determine:

- (i) The probability that the investor meets the target profit exactly 4 times.
- (ii) The probability that the investor meets the target profit at least once.
- (iii) The expected value.
- (iv) The variance.



✓ Answer for Question 1b

This problem can be modeled using the **Binomial Distribution**, where:

- $n=8$ (number of investment trials)
- $p=0.12$ (probability of achieving the target profit/success)
- $q=1-p=0.88$ (probability of failure)
- X is the random variable representing the number of successes.

The binomial probability formula is given by:

$$P(X = k) = \binom{n}{k} p^k q^{n-k}$$

(i) The probability that the investor meets the target profit exactly 4 times

We need to find $P(X=4)$:

$$P(X = 4) = \binom{8}{4} (0.12)^4 (0.88)^{8-4}$$

$$P(X = 4) = 70 \times (0.12)^4 \times (0.88)^4$$

$$P(X = 4) \approx 70 \times 0.00020736 \times 0.599695$$

$$P(X = 4) \approx 0.0087$$

The probability is approximately 0.0087.

(ii) The probability that the investor meets the target profit at least once

The probability of "at least once" is easiest to calculate by subtracting the probability of "never" from 1:

$$P(X \geq 1) = 1 - P(X = 0)$$

First, find $P(X = 0)$:



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Question 2b

□ Correlation Analysis, Regression Analysis



The number of hours spent studying for an examination by 8 students together with the marks achieved in the examination are given in the table below:

Time (X)	2	3	4	5	6	7	8	9
Marks (Y)	40	38	54	44	54	58	70	80

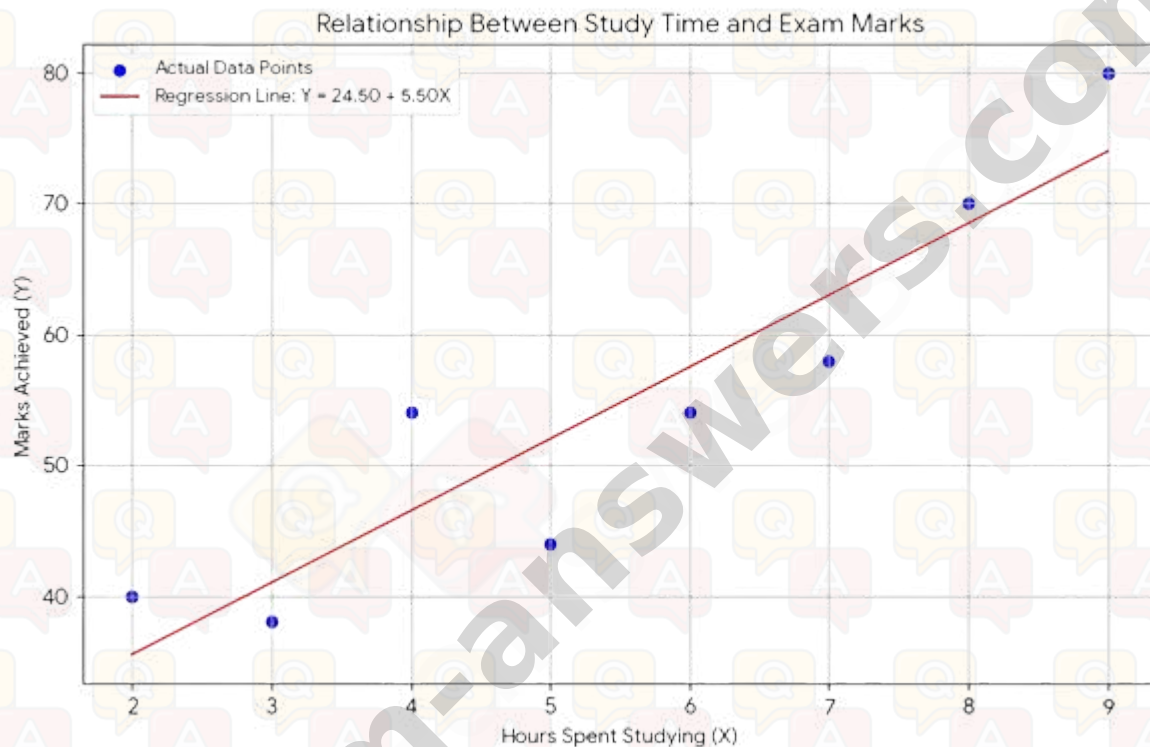
Required:

- (i) Draw a scatter diagram to represent the above data.
- (ii) Comment on the nature of the relationship obtained in (b) (i) above.
- (iii) Calculate the regression of Y and X.
- (iv) Fit the regression equation obtained in (b) (iii) above on the same axis in the scatter diagram in (b) (i) above.

✓ Answer for Question 2b

(i) Scatter Diagram

The scatter diagram below represents the relationship between hours spent studying (X) and the marks achieved (Y). Each blue dot represents an individual student's data point.



(ii) Nature of the Relationship

Based on the scatter diagram, there is a **strong positive linear correlation** between the number of hours spent studying and the marks achieved. As the study time increases, the marks generally tend to increase as well.

(iii) Calculation of the Regression of Y on X

The regression equation is represented as $Y = a + bX$.

n	X	Y	XY	X^2
1	2	40	80	4



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Question 6b

☐ Decision Theory



Jumbo Ltd. has to make a decision on whether to invest in project A, B or C. The economic conditions could be favourable, moderate or unfavourable.

The table below shows the potential payoffs in thousands of shillings (Sh."000") depending on the market conditions and their associated probabilities:

Project	Economic conditions		
	Favourable	Moderate	Unfavourable
A	7,300	5,600	4,100
B	15,100	6,700	0
C	9,500	6,000	2,500
Probability	0.20	0.30	0.50

Required:

Advise the management of Jumbo Ltd. of the most optimal decision using:

- (i) Maximax criterion.
- (ii) Maximin criterion.
- (iii) Laplace criterion.
- (iv) Expected monetary value (EMV) criterion.

✓ Answer for Question 6b

(i) Maximax Criterion (Optimistic Approach)

This criterion seeks to maximize the maximum possible payoff.

Payoff Table (in Sh.'000):

Project	Favourable(0.20)	Moderate(0.30)	Unfavourable(0.50)	Maximax
A	7,300	5,600	4,100	7,300
B	15,100	6,700	0	15,100
C	9,500	6,000	2,500	9,500

The highest among these is **15,100** from Project B.

Decision using Maximax: Choose Project B

(ii) Maximin Criterion (Pessimistic Approach)

This criterion seeks to maximize the minimum possible payoff.

Project	Favourable(0.20)	Moderate(0.30)	Unfavourable(0.50)	Maximin
A	7,300	5,600	4,100	4,100
B	15,100	6,700	0	0
C	9,500	6,000	2,500	2,500

The highest among these is **4,100** from Project A.

Decision using Maximin: Choose Project A



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Quantitative Analysis

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Level: Foundation Level

Question 1a

□ Mathematical Techniques - Calculus

Explain TWO applications of calculus in business management.



✓ Answer for Question 1a

Applications of Calculus in Business Management

Calculus (especially differential and integral calculus) is a powerful tool in business management for optimizing operations, forecasting, and decision-making. Here are key applications:

1. Marginal Analysis (Derivatives)

- **Concept:** Derivatives measure the rate of change (e.g., marginal cost, marginal revenue).
- **Applications:**
 - **Profit Maximization:** Find where marginal revenue (MR) equals marginal cost (MC).
 - Solve $\frac{d(\text{Revenue})}{dq} = \frac{d(\text{Cost})}{dq}$ for output q .
 - **Pricing Strategies:** Determine optimal pricing by analyzing demand elasticity.
 - **Resource Allocation:** Optimize input usage (e.g., labor, capital) using marginal productivity.

2. Optimization (First and Second Derivatives)

- **Concept:** Find maxima/minima of functions (e.g., profit, cost).
- **Applications:**
 - **Inventory Management:** Minimize total inventory costs (ordering + holding costs) using EOQ model.
 - **Production Planning:** Determine optimal production levels to minimize costs or maximize output.
 - **Portfolio Management:** Maximize returns or minimize risk in finance.



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Question 1b

Mathematical Techniques - Calculus

Find the area between the curve $y = x + 2x + \frac{1}{x^2}$, the x axis and the lines $x = 1$ and $x = 2$.



✓ Answer for Question 1b

Find the area between the curve $y = x + 2x + \frac{1}{x^2}$, the x-axis, and the lines $x = 1$ and $x = 2$.

First, simplify the function:

$$y = x + 2x + \frac{1}{x^2} = 3x + \frac{1}{x^2}$$

The area A under the curve from $x = 1$ to $x = 2$ is given by the definite integral:

$$A = \int_1^2 \left(3x + \frac{1}{x^2} \right) dx$$

Now, compute the integral step by step.

1. Find the antiderivative:

- The antiderivative of $3x$ is $\frac{3}{2}x^2$.
- The antiderivative of $\frac{1}{x^2}$ is:
- $\frac{1}{x^2} = x^{-2}$ is $\frac{x^{-1}}{-1} = -\frac{1}{x}$.

So, the antiderivative $F(x)$ is:

$$F(x) = \frac{3}{2}x^2 - \frac{1}{x}$$

2. Evaluate the definite integral:

$$A = \left[\frac{3}{2}x^2 - \frac{1}{x} \right]_1^2$$

First, evaluate at $x = 2$:

$$F(2) = \frac{3}{2}(2)^2 - \frac{1}{2}$$

$$F(2) = \frac{3}{2} * 4 - \frac{1}{2}$$



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Quantitative Analysis

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Question 2a

□ Mathematical Techniques - Differentiation



Shoetec Ltd., a manufacturer of stylish shoes, estimates that at full scale production, it would sell between 2,000 and 3,000 pairs of shoes.

The total monthly revenue in thousands of shillings over this range is represented by the function

$$TR = 3x^2 + 7x.$$

The firm estimates that the marginal cost (MC) in thousands of shillings could be represented by the function

$$MC = 5x^2 - 3x - 2 \text{ and fixed cost (FC) will be Sh.1,000 per month.}$$

Where x is the monthly output in thousands of pairs of shoes.

Required:

- (i) Derive the average cost and average revenue functions of the firm.
- (ii) Calculate the profit maximising output.
- (iii) Calculate the price charged upon maximising profit and how much each pair of shoes would cost.

✓ Answer for Question 2a

(i) Average Cost (AC) and Average Revenue (AR) Functions

TC is the integral of MC:

$$\begin{aligned} TC &= \int MC \, dx = \int (5x^2 - 3x - 2) \, dx \\ &= \frac{5}{3}x^3 - \frac{3}{2}x^2 - 2x + C \end{aligned}$$

At $X = 0$, $TC = FC = 1$ (thousand shillings), so $C = 1$.

$$TC = \frac{5}{3}x^3 - \frac{3}{2}x^2 - 2x + 1$$

$$\begin{aligned} AC &= \frac{TC}{x} \\ &= \frac{\frac{5}{3}x^3 - \frac{3}{2}x^2 - 2x + 1}{x} \end{aligned}$$

$$= \frac{5}{3}x^2 - \frac{3}{2}x - 2 + \frac{1}{x}$$

$$AR = \frac{TR}{x} = \frac{3x^2 + 7x}{x} = 3x + 7$$

(ii) Profit-Maximizing Output

Profit (π)

$$\pi = TR - TC$$

$$\pi = (3x^2 + 7x) - \left(\frac{5}{3}x^3 - \frac{3}{2}x^2 - 2x + 1 \right)$$