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Taha Math Academy

Grade 12 • Advanced Track

Reveal

Questions

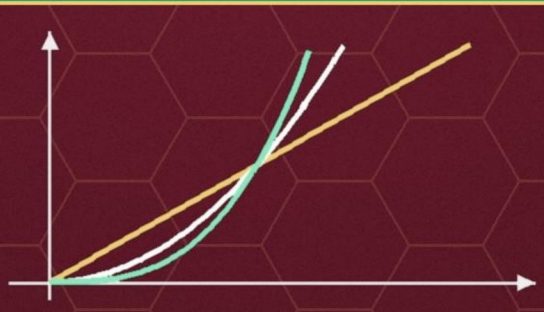
56

Exam Coverage Questions • Term 1

FRQ Part

Free Response • Without Solutions

Items 21 to 26



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Item 21a: Determine the continuity of a function at a given point

Lesson 2-4: Continuity and Its Consequences • Book p. 88 • Definition 4.1

Questions: two teacher-made questions + past ministry (MOE) questions

Item 21a • Summary of Rules

Definition of Continuity (4.1)

$$\lim_{x \to a} f(x) = f(a)$$

Three Conditions of Continuity

$$(1)\ f(a) \qquad (2)\ \lim_{x \to a} f(x) \qquad (3)\ \lim_{x \to a} f(x) = f(a)$$

the function value is defined, the limit exists, and they are equal

One-sided Continuity

$$\lim_{x \to a^+} f(x) = f(a), \qquad \lim_{x \to a^-} f(x) = f(a)$$

Continuity Where the Pieces Meet

$$\lim_{x \to a^-} f(x) = \lim_{x \to a^+} f(x) = f(a)$$

Q1 Basic 2 marks Teacher-made

Continuity Piecewise Function

Determine the continuity of the following function at the given point using the definition of continuity:

$$f(x) = \begin{cases} x+1, & x < 1 \\ 3x-1, & x \geq 1 \end{cases}, \qquad x = 1$$

Solution:

Q2 Basic 2 marks Teacher-made

Continuity Removable Discontinuity

Determine the continuity of the following function at the given point using the definition of continuity:

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

Solution:

Past MOE Exam Questions • Item 21a

Learning outcome: Determine the continuity of a function at a given point

Q3 | Intermediate | 3 marks | ★ MOE 2024-2025 FRQ 1a

Continuity | Piecewise Function

Determine the values of a and b that make the following function continuous:

$$f(x) = \begin{cases} 2, & x \leq -1 \\ ax + b, & -1 < x < 3 \\ -2, & x \geq 3 \end{cases}$$

Solution:

Q4 | Intermediate | 3 marks | ★ MOE 2020-2021 Q13

Continuity | Removable Discontinuity

Determine the values of the constants m and n that make the following function continuous at the given point:

$$h(x) = \begin{cases} \dfrac{x^2 - mx + 2}{x - 1}, & x \neq 1 \\ n, & x = 1 \end{cases} \qquad x = 1$$

Solution:

Q5 | Intermediate | 3 marks | ★ MOE 2019-2020 Q9

Continuity | Nonremovable Discontinuity

Find all points at which the following function is discontinuous, and determine whether each discontinuity is removable:

$$f(x) = \begin{cases} \sin x, & x < 0 \\ x^2, & 0 \le x \le 2 \\ 4x - 3, & x > 2 \end{cases}$$

Solution:

Q6 | Advanced | 4 marks | ★ MOE 2018-2019 Q8

Continuity | Piecewise Function

Determine the values of a and b that make the following function continuous:

$$f(x)=\begin{cases} a\left(\tan^{-1}x+2\right), & x<0 \\ b\cos\left[\left(x+\frac{1}{3}\right)\pi\right], & 0\le x\le 3 \\ \ln(x-2)+x^2+1, & x>3 \end{cases}$$

Solution:

Q7 | Basic | 2 marks | ★ MOE 2016-2017 Q2

Continuity | Removable Discontinuity

The following function is defined for all real numbers except the given point. Find the value the function should be defined to have at this point to make it continuous there:

$$g(x)=\frac{1-x^3}{1-x}, \qquad x\neq 1$$

Solution:

Item 21b: Use the continuity properties to study the continuity of a function or a composition of functions at a given point

Lesson 2-4: Continuity and Its Consequences • Book p. 95

Book questions: Exercises 29–32 • two teacher-made questions

Item 21b • Summary of Rules

Continuity at a Point

$$\lim_{x \to a^-} f(x) = \lim_{x \to a^+} f(x) = f(a)$$

Properties (Theorem 4.2)

$$f \pm g, \qquad f \cdot g, \qquad \frac{f}{g} \quad (g(a) \neq 0)$$

continuous at the point if both functions are continuous there

Composition (Corollary 4.1)

$$\lim_{x \to a} f(g(x)) = f(g(a))$$

the inner function is continuous at the point, and the outer function is continuous at its image

Polynomials (Theorem 4.1)

$$\lim_{x \to a} p(x) = p(a)$$

each linear piece of the tax function is continuous

Q1 | Basic | 2 marks | Book p. 95 • Exercise 29

Continuity | Piecewise Function

The following function represents the tax Mr. Mohamed Taha pays on an income of x. Find the value of the constant c that makes the function continuous for all real numbers:

$$T(x) = \begin{cases} 0, & x \leq 0 \\ 0.14x, & 0 < x < 10000 \\ c + 0.21x, & 10000 \leq x \end{cases}$$

Solution:

Q2 | Basic | 2 marks | Book p. 95 • Exercise 32

Continuity | Piecewise Function

The following function represents part of a tax function on an income of x. Show that the function is continuous at the given point:

$$T(x) = \begin{cases} 0.10x, & 0 < x \leq 6000 \\ 0.15x - 300, & 6000 < x \leq 27950 \end{cases} \qquad x = 6000$$

Solution:

Q3 | Intermediate | 3 marks | Book p. 95 • Exercise 30

Continuity | Piecewise Function

The following function represents the tax on an income of x. Find the values of the constants a and b that make the function continuous for all real numbers:

$$T(x) = \begin{cases} 0, & x \leq 0 \\ a + 0.12x, & 0 < x \leq 20000 \\ b + 0.16(x - 20000), & x > 20000 \end{cases}$$

Solution:

Q4 | Intermediate | 3 marks | Teacher-made

Composite Function | Continuity

Use properties of continuity to determine whether the composite function h is continuous at the given point:

$$h(x) = f(g(x)), \qquad f(x) = \sqrt{x}, \qquad g(x) = x^2 - 5, \qquad x = 3$$

Solution:

Q5 | Advanced | 4 marks | Book p. 95 • Exercise 31

Continuity | Piecewise Function

The following function represents part of a tax function on an income of x. Find the values of the constants b and c that make the function continuous:

$$T(x) = \begin{cases} 0.30x - 5685, & 67700 < x \leq 141250 \\ 0.35x - b, & 141250 < x \leq 307050 \\ 0.386x - c, & x > 307050 \end{cases}$$

Solution:

Q6 | Advanced | 4 marks | Teacher-made

Continuity | Removable Discontinuity

Determine whether the following function is continuous at the given point, and identify the type of discontinuity, if any:

$$h(x) = \frac{\sqrt{x+2} - 2}{x - 2}, \quad x = 2$$

Solution:

Item 22: Find horizontal, vertical, and slant asymptotes using limits

Lesson 2-5: Limits Involving Infinity; Asymptotes • Book p. 106

Book questions: Exercises 29–32 • two teacher-made questions + past ministry (MOE) questions

Item 22 • Summary of Rules

Vertical Asymptote

$$\lim_{x \to a^{\pm}} f(x) = \pm\infty \;\Rightarrow\; x = a$$

Zeros of the denominator that do not cancel

Slant Asymptote

$$\lim_{x \to \pm\infty} [f(x) - (mx + b)] = 0 \;\Rightarrow\; y = mx + b$$

the degree of the numerator is one more than the degree of the denominator

Long Division

$$\frac{p(x)}{q(x)} = mx + b + \frac{r(x)}{q(x)}$$

the degree of the remainder is less than the degree of the denominator

Horizontal Asymptote

$$\lim_{x \to \pm\infty} f(x) = L \;\Rightarrow\; y = L$$

Q1 | Basic | 2 marks | Book p. 106 • Exercise 30 • MOE 2017-2018

Vertical Asymptote | Slant Asymptote

Determine all vertical and slant asymptotes of the graph of the following function:

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

Solution:

Q2 | Basic | 2 marks | Teacher-made

Vertical Asymptote | Slant Asymptote

Determine all vertical and slant asymptotes of the graph of the following function:

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

Solution:

Q3 | Intermediate | 3 marks | Book p. 106 • Exercise 29 • MOE 2021-2022

Vertical Asymptote | Slant Asymptote

Determine all vertical and slant asymptotes of the graph of the following function:

$$y = \frac{x^3}{4 - x^2}$$

Solution:

Q4 | Intermediate | 3 marks | Book p. 106 • Exercise 31 • MOE 2020-2021

Vertical Asymptote | Slant Asymptote

Determine all vertical and slant asymptotes of the graph of the following function:

$$y = \frac{x^3}{x^2 + x - 4}$$

Solution:

Q5 | Advanced | 4 marks | Book p. 106 • Exercise 32

Vertical Asymptote | Slant Asymptote

Determine all vertical and slant asymptotes of the graph of the following function:

$$y = \frac{x^4}{x^3 + 2}$$

Solution:

Q6 | Advanced | 4 marks | Teacher-made

Vertical Asymptote | Slant Asymptote

Determine all vertical and slant asymptotes of the graph of the following function:

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

Solution:

Past MOE Exam Questions • Item 22

Learning outcome: Find horizontal, vertical, and slant asymptotes using limits

Q7 | Intermediate | 3 marks | ★ MOE 2024-2025 FRQ 1b

Limit at Infinity | Horizontal Asymptote

The length of a small animal in millimeters t days after birth is given by the following function. Find its length at birth, then find its final length in the long run:

$$h(t) = \frac{350}{2 + 8(0.8)^t}$$

Solution:

Q8 | Advanced | 4 marks | ★ MOE 2023-2024 FRQ 1b

Limit at Infinity | Conjugate

Find the following limit:

$$\lim_{x \to \infty} \left(\sqrt{4x^2 - 2x + 1} - 2x \right)$$

Solution:

Q9 | Intermediate | 3 marks | ★ MOE 2023-2024 Q5 (adapted as FRQ)

Vertical Asymptote | Slant Asymptote

Determine all vertical and slant asymptotes of the graph of the following function:

$$f(x) = \frac{x^3}{x^2 + x - 6}$$

Solution:

Item 23: Apply the Product Rule to derivatives

Lesson 3-4: The Product and Quotient Rules • Book p. 169

Book questions: Exercises 17–20 • teacher-made question + past ministry (MOE) questions

Item 23 • Summary of Rules

Product Rule

$$[f(x)\,g(x)]' = f'(x)\,g(x) + f(x)\,g'(x)$$

Quotient Rule

$$\left[\frac{f(x)}{g(x)}\right]' = \frac{f'(x)\,g(x) - f(x)\,g'(x)}{[g(x)]^2}, \quad g(x) \neq 0$$

Equation of the Tangent Line

$$y = f(a) + f'(a)\,(x - a), \qquad m = f'(a)$$

the slope is the value of the derivative at the point of tangency

Rate of Change of Revenue

$$R = Q \cdot P \;\Rightarrow\; R' = Q'P + QP'$$

Revenue is the quantity sold times the unit price

Q1 | Basic | 2 marks | Book p. 169 • Exercise 17

Equation of the Tangent Line | Product Rule

Find the equation of the tangent line to the graph of the following function at the given value:

$$f(x) = (x^2 + 2x)(x^4 + x^2 + 1), \qquad x = 0$$

Solution:

Q2 | Basic | 2 marks | Teacher-made

Equation of the Tangent Line | Product Rule

Find the equation of the tangent line to the graph of the following function at the given value:

$$f(x) = (x + 1)(x^2 - 3), \qquad x = 1$$

Solution:

Q3 | Intermediate | 3 marks | Book p. 169 • Exercise 18

Equation of the Tangent Line | Product Rule

Find the equation of the tangent line to the graph of the following function at the given value:

$$f(x) = (x^3 + x + 1)(3x^2 + 2x - 1), \qquad x = 1$$

Solution:

Q4 | Intermediate | 3 marks | Book p. 169 • Exercise 19

Equation of the Tangent Line | Quotient Rule

Find the equation of the tangent line to the graph of the following function at the given value:

$$f(x) = \frac{x+1}{x+2}, \qquad x = 0$$

Solution:

Q5 | Advanced | 4 marks | Book p. 169 • Exercise 20

Equation of the Tangent Line | Quotient Rule

Find the equation of the tangent line to the graph of the following function at the given value:

$$f(x) = \frac{x+3}{x^2+1}, \qquad x = 1$$

Solution:

Past MOE Exam Questions • Item 23

Learning outcome: Apply the Product Rule to derivatives

Q6 | Advanced | 4 marks | ★ MOE 2019-2020 Q12

Revenue | Rate of Change | Product Rule

A store sells an item now priced at 2.4 dirhams, and its price is increasing at a rate of 0.1 dirham per year. It currently sells 12000 items per year, and sales are decreasing at a rate of 1500 items per year. Revenue is the product of the price and the number of items sold. At what rate is the revenue changing now?

Solution:

Q7 | Advanced | 4 marks | ★ MOE 2017-2018 Q18

Revenue | Rate of Change | Product Rule

A company sells an item now priced at 12 dirhams, and currently sells 10000 items per year. The company wants to increase its sales at a rate of 1000 items per year and to increase its revenue at a rate of 15000 dirhams per year. Revenue is the product of the price and the number of items sold. At what rate must the price of the item increase?

Solution:

Q8 | Intermediate | 3 marks | ★ MOE 2016-2017 Q17

Revenue | Rate of Change | Product Rule

An item now costs 18 dirhams, and its price is increasing at a rate of 1.25 dirhams per year. Currently 2000 items are sold per year, and sales are increasing at a rate of 200 items per year. Revenue is the product of the price and the number of items sold. At what rate is the total revenue increasing now?

Solution:

Item 24: Find the derivatives of trigonometric functions using differentiation rules

Lesson 3-6: Derivatives of Trigonometric Functions • Book p. 184

Book questions: Exercises 3–8 + past ministry (MOE) questions

Item 24 • Summary of Rules

Derivatives of sin and cos

$$\frac{d}{dx}\sin x = \cos x, \qquad \frac{d}{dx}\cos x = -\sin x$$

both valid for all real numbers

Derivatives of tan and cot

$$\frac{d}{dx}\tan x = \sec^2 x, \qquad \frac{d}{dx}\cot x = -\csc^2 x$$

both valid on the domain of each function

Derivatives of sec and csc

$$\frac{d}{dx}\sec x = \sec x \tan x, \qquad \frac{d}{dx}\csc x = -\csc x \cot x$$

both valid on the domain of each function

Chain Rule

$$\frac{d}{dx}\left[f(g(x))\right] = f'(g(x)) \cdot g'(x)$$

outer derivative at the inner function × inner derivative

Product Rule

$$[f\,g]' = f'g + fg'$$

Q1 | Basic | 2 marks | Book p. 184 • Exercise 4

Derivative | Chain Rule

Find the derivative of the following function:

$$f(t) = t^2 + 2\cos^2 4t$$

Solution:

Q2 | Basic | 2 marks | Book p. 184 • Exercise 6

Derivative | Product Rule

Find the derivative of the following function:

$$f(x) = x^2 \sec 4x$$

Solution:

Q3 | Intermediate | 3 marks | Book p. 184 • Exercise 3

Derivative | Chain Rule

Find the derivative of the following function:

$$f(t) = \tan^3 2t - \csc^4 3t$$

Solution:

Q4 | Intermediate | 3 marks | Book p. 184 • Exercise 5

Derivative | Product Rule | Chain Rule

Find the derivative of the following function:

$$f(x) = x \cos 5x^2$$

Solution:

Q5 | Advanced | 4 marks | Book p. 184 • Exercise 7 • MOE 2020-2021

Derivative | Quotient Rule | Chain Rule

Find the derivative of the following function:

$$f(x) = \frac{\sin x^2}{x^2}$$

Solution:

Q6 | Advanced | 4 marks | Book p. 184 • Exercise 8

Derivative | Product Rule | Chain Rule

Find the derivative of the following function:

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

Solution:

Past MOE Exam Questions • Item 24

Learning outcome: Find the derivatives of trigonometric functions using differentiation rules

Q7 | Intermediate | 3 marks | ★ MOE 2019-2020 Q17

Equation of the Tangent Line | Product Rule

Find the equation of the tangent line to the graph of the following function at the given value:

$$f(x) = x \sin x, \qquad x = \frac{\pi}{2}$$

Solution:

Q8 | Advanced | 4 marks | ★ MOE 2018-2019 Q14

Velocity | Trigonometric Functions

A spring hanging from the ceiling oscillates vertically, and its position after t seconds is given by the following function. Find the position of the spring when its velocity is zero.

$$f(t) = 4\cos 2t, \qquad 0 \le t \le \pi$$

Solution:

Item 25: Solve real-life problems using derivatives of exponential and logarithmic functions

Lesson 3-7: Derivatives of Exponential and Logarithmic Functions • Book p. 194

Book questions: Exercises 35–38 • teacher-made question + past ministry (MOE) questions

Item 25 • Summary of Rules

Instantaneous Percentage Rate of Change

$$100 \cdot \frac{f'(t)}{f(t)} \ \%$$

Derivative of a^x

$$\frac{d}{dx}a^x = a^x \ln a, \qquad \frac{d}{dx}a^u = a^u \ln a \cdot u', \qquad a > 0$$

Derivative of e^x

$$\frac{d}{dx}e^x = e^x, \qquad \frac{d}{dx}e^u = e^u \, u'$$

the exponential function is defined and differentiable for all real numbers

Exponential Growth

$$P(t) = P_0 \, b^{t/T}$$

the quantity is multiplied by the same factor every fixed time period

Limit of a Decaying Exponential

$$\lim_{t \to \infty} e^{-kt} = 0, \quad k > 0$$

Q1 | Basic | 2 marks | Book p. 194 • Exercise 35

Percentage Rate of Change | Exponential Growth

A bacterial population has P cells after t days; it starts with the given number and triples every day. Find a formula for the number of cells, then find the instantaneous percentage rate of change of the number of cells.

$$P(0) = 200$$

Solution:

Q2 | Basic | 2 marks | Teacher-made

Exponential Function | Derivative

The value of Mr. Mohamed Taha's investment in dirhams after t years is given by the following function. Find the rate of change of the investment's value at t = 10, rounded to the nearest hundredth.

$$v(t) = 2000e^{0.05t}$$

Solution:

Q3 | Intermediate | 3 marks | Book p. 194 • Exercise 36

Percentage Rate of Change | Exponential Growth

A bacterial population has P cells after t days; it starts with the given number and doubles every four days. Find a formula for the number of cells, then find the instantaneous percentage rate of change of the number of cells.

$$P(0) = 500$$

Solution:

Q4 | Advanced | 4 marks | Book p. 194 • Exercise 37 • MOE 2023-2024 • 2019-2020

Derivative | Exponential Function | Quotient Rule

In an autocatalytic chemical reaction, the concentration of a substance after t seconds is given by the following function. Show that the derivative of the function is always positive, then conclude that the concentration never exceeds 6.

$$c(t) = \frac{6}{2e^{-8t} + 1}$$

Solution:

Q5 | Advanced | 4 marks | Book p. 194 • Exercise 38

Derivative | Exponential Function | Quotient Rule

In an autocatalytic chemical reaction, the concentration of a substance after t seconds is given by the following function. Show that the derivative of the function is always positive, then conclude that the concentration never exceeds 5.

$$c(t) = \frac{10}{9e^{-10t} + 2}$$

Solution:

Past MOE Exam Questions • Item 25

Learning outcome: Solve real-life problems using derivatives of exponential and logarithmic functions

Q6 | Intermediate | 3 marks | ★ MOE 2021-2022 Q14

Percentage Rate of Change | Exponential Function

The value of an investment after t years is given by the following function. Find the instantaneous percentage rate of change of the investment's value.

$$v(t) = 60e^{-0.2t}$$

Solution:

Q7 | Intermediate | 3 marks | ★ MOE 2019-2020 Q18

Percentage Rate of Change | Exponential Growth

An investment doubles in value every year, and its value in dirhams after t years is given by the following function. Find the instantaneous percentage rate of change of the value of the investment.

$$v(t) = 100(2)^t$$

Solution:

Item 26: Understand the Mean Value Theorem and use it in applications

Lesson 3-10: The Mean Value Theorem • Book p. 219

Book questions: Exercises 1–6 + past ministry (MOE) questions

Item 26 • Summary of Rules

Mean Value Theorem

$$f'(c) = \frac{f(b) - f(a)}{b - a}, \quad c \in (a, b)$$

provided the function is continuous on the closed interval and differentiable on the open interval

Rolle's Theorem as a Special Case

$$f(a) = f(b) \Rightarrow f'(c) = 0, \quad c \in (a, b)$$

when the function values at the two endpoints are equal

Polynomials

$$p(x) = a_n x^n + \cdots + a_1 x + a_0, \qquad x \in \mathbb{R}$$

continuous and differentiable for all real numbers

Increasing and Decreasing

$$f'(x) < 0 \Rightarrow f(a) > f(b), \quad a < b$$

a negative derivative means the function is decreasing, and a positive one means it is increasing

Q1 | Basic | 2 marks | Book p. 219 • Exercise 1

Rolle's Theorem | Mean Value Theorem | Hypotheses

Verify the hypotheses of Rolle's Theorem and the Mean Value Theorem for the following function on the given interval, then find the value of c that makes the appropriate conclusion true:

$$f(x) = x^2 + 1, \qquad [-2, 2]$$

Solution:

Q2 | Basic | 2 marks | Book p. 219 • Exercise 2

Mean Value Theorem | Hypotheses

Verify the hypotheses of Rolle's Theorem and the Mean Value Theorem for the following function on the given interval, then find the value of c that makes the appropriate conclusion true:

$$f(x) = x^2 + 1, \qquad [0, 2]$$

Solution:

Q3 | Intermediate | 3 marks | Book p. 219 • Exercise 4

Mean Value Theorem | Hypotheses

Verify the hypotheses of Rolle's Theorem and the Mean Value Theorem for the following function on the given interval, then find the value of c that makes the appropriate conclusion true:

$$f(x) = x^3 + x^2, \qquad [-1, 1]$$

Solution:

Q4 | Intermediate | 3 marks | Book p. 219 • Exercise 6

Rolle's Theorem | Mean Value Theorem | Hypotheses

Verify the hypotheses of Rolle's Theorem and the Mean Value Theorem for the following function on the given interval, then find the value of c that makes the appropriate conclusion true:

$$f(x) = \sin x, \qquad [-\pi, 0]$$

Solution:

Q5 | Advanced | 4 marks | Book p. 219 • Exercise 3

Mean Value Theorem | Hypotheses

Verify the hypotheses of Rolle's Theorem and the Mean Value Theorem for the following function on the given interval, then find the value of c that makes the appropriate conclusion true:

$$f(x) = x^3 + x^2, \qquad [0, 1]$$

Solution:

Q6 | Advanced | 4 marks | Book p. 219 • Exercise 5 • MOE 2024-2025

Mean Value Theorem | Hypotheses

Verify the hypotheses of Rolle's Theorem and the Mean Value Theorem for the following function on the given interval, then find the value of c that makes the appropriate conclusion true:

$$f(x) = \sin x, \qquad \left[0, \frac{\pi}{2}\right]$$

Solution:

Past MOE Exam Questions • Item 26

Learning outcome: Understand the Mean Value Theorem and use it in applications

Q7 | Basic | 2 marks | ★ MOE 2022-2023 Q23 | Mean Value Theorem

Find the value of c that satisfies the conclusion of the Mean Value Theorem for the following function on the given interval:

$$f(x) = x^2 - 2x, \qquad [0,\ 2]$$

Solution:

Q8 | Basic | 2 marks | ★ MOE 2021-2022 Q25 • 2019-2020 Q15

Mean Value Theorem

Find the value of c that satisfies the conclusion of the Mean Value Theorem for the following function on the given interval:

$$f(x) = x^2 + 2, \qquad [0, 2]$$

Solution:

Q9 | Basic | 2 marks | ★ MOE 2017-2018 Q19 | Mean Value Theorem

Find the value of c that satisfies the conclusion of the Mean Value Theorem for the following function on the given interval:

$$f(x) = x^2 + 2x + 1, \qquad [0, 1]$$

Solution:

Q10 | Intermediate | 3 marks | ★ MOE 2023-2024 FRQ 5

Mean Value Theorem | Hypotheses

Verify the hypotheses of the Mean Value Theorem for the following function on the given interval, then find the value of c that makes the conclusion of the theorem true:

$$f(x) = x^3 + x, \qquad [-1, 0]$$

Solution:

Q11 | Intermediate | 3 marks | ★ MOE 2018-2019 Q15

Decreasing Function | Mean Value Theorem

Show that the following function is decreasing:

$$F(x) = 3 - x + e^{-x}$$

Solution: