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Write your **student number** in the boxes above. **Letter**

Mathematical Methods
Examination 1

Question and Answer Book

VCE (NHT) Examination – Tuesday 26 May 2026

- Reading time is **15 minutes**: 10.30 am to 10.45 am
- Writing time is **1 hour**: 10.45 am to 11.45 am

Materials supplied

- Question and Answer Book of 16 pages
- Formula Sheet

Students are **not** permitted to bring any technology (calculators or software), or notes of any kind, into the examination room.

Students are **not** permitted to bring mobile phones and/or any unauthorised electronic devices into the examination room.

Contents

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Examination questions start on the next page.

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Instructions

- Answer **all** questions in the spaces provided.
- Write your responses in English.
- In all questions where a numerical answer is required, an **exact** value must be given unless otherwise specified.
- In questions where more than one mark is available, appropriate working **must** be shown.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1 (4 marks)

a. Let $y = x^3 \log_e(5x)$.

Find $\dfrac{dy}{dx}$. 2 marks

b. Let $f'(x) = (x-2)^3$.

Find $f(x)$, where $f(1) = 1$. 2 marks

Question 2 (3 marks)

Consider the graph of the function with the rule $y = \frac{m}{x+a} + c$, where $a, c, m \in Z$.

It has an x-intercept $(-8, 0)$, a y-intercept $(0, 24)$, a vertical asymptote $x = -6$ and a horizontal asymptote.

Find the values of a, c and m.

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Question 3 (5 marks)

Visitors to a popular location purchase different tickets according to the time spent there.
The table below outlines the ticket price per visitor.

Time spent	less than 10 minutes	10 to 20 minutes	more than 20 minutes
Ticket price	\$5	\$8	\$12

It is known that of all visitors:

- 60% purchased tickets for less than 10 minutes
- 25% purchased tickets for 10 to 20 minutes
- 15% purchased tickets for more than 20 minutes.

a. Find the probability that a randomly selected visitor purchased a ticket for 20 minutes or less. 1 mark

b. Find the mean ticket price, in dollars, purchased by a randomly selected visitor. 2 marks

c. A random sample of five visitors is selected from a large group of visitors.

Find the probability that exactly four of the five visitors purchased tickets for less than 10 minutes. 2 marks

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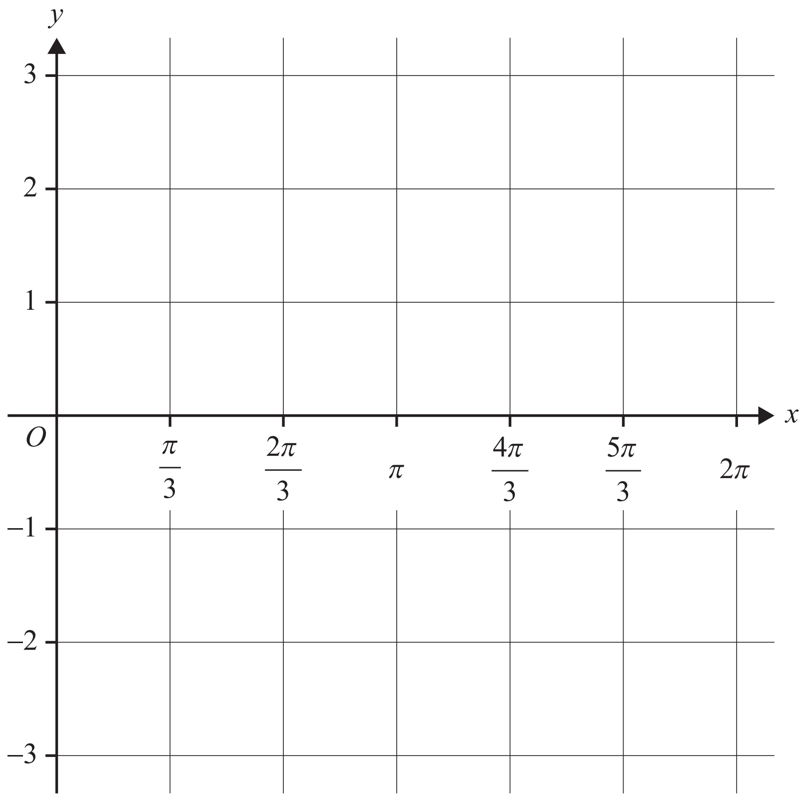
Question 4 (4 marks)

Consider the function $f:[0, 2\pi] \to R,\ f(x) = 2\sin\left(x - \frac{\pi}{6}\right)$.

a. Evaluate $f(0)$. 1 mark

b. Sketch the graph of $y = f(x)$ on the axes below.

Label the coordinates of the turning points and x-intercepts. 3 marks



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Question 5 (4 marks)

Consider the function with the rule $f(x) = \tan(2x) + 2$ and maximal domain.

a. Find the equations of the vertical asymptotes for the graph of $y = f(x)$. 1 mark

b. Determine $f'(x)$. 1 mark

c. Find the area of the region bounded by the curve $y = f'(x)$, the line $x = \frac{\pi}{12}$, the line $x = \frac{\pi}{6}$ and the x-axis. 2 marks

Question 6 (2 marks)

Let X be a normal random variable.

Let a and b be real numbers, where $a < b$.

If $\Pr(X < a) = m$ and $\Pr(X < b) = n$, find, in terms of m and n, $\Pr(X > a \mid X < b)$.

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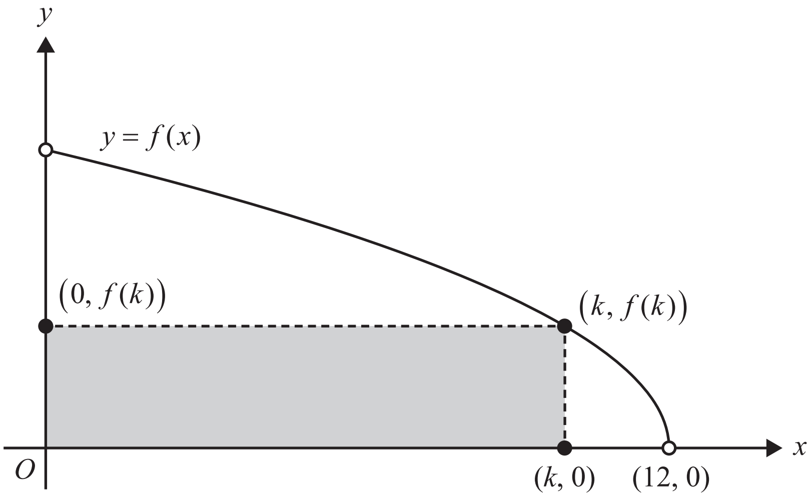
Question 7 (3 marks)

Let $f:(0,12) \rightarrow R,\ f(x)=\sqrt{12-x}$.

A rectangle is inscribed on the graph of $y=f(x)$ so that it has a vertex at the origin and the diagonally opposite vertex at $(k,\ f(k))$, where $0<k<12$, as shown below.



a. Show that the area of the rectangle can be expressed as $A(k)=\sqrt{12k^2-k^3}$. 1 mark

b. Determine the value of k that maximises the area of the rectangle. 2 marks

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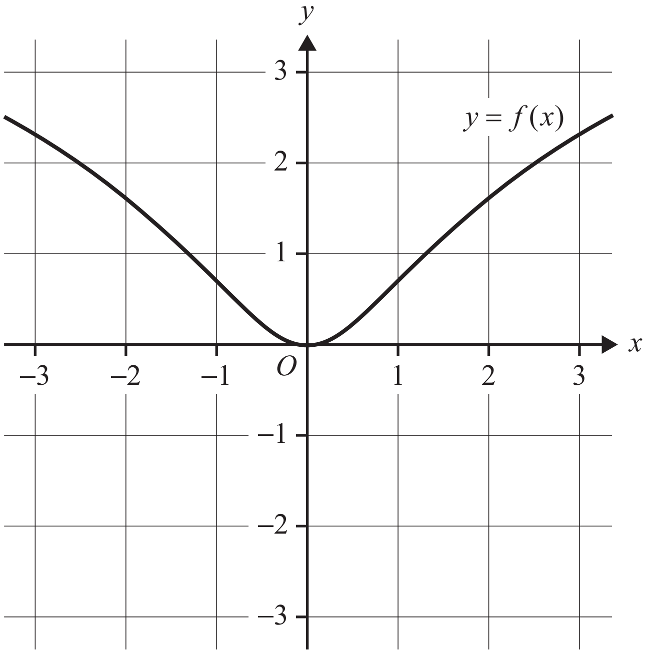
Question 8 (6 marks)

Let $f : R \to R,\ f(x) = \log_e(1 + x^2)$.

The graph of $y = f(x)$ is shown below.



Let $g : R \to R,\ g(x) = 2 - f(x)$.

a. Determine the coordinates of the points of intersection of the graphs of $y = f(x)$ and $y = g(x)$. 3 marks

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b. Sketch the graph of $y = g(x)$ on the axes on page 10.

Label the coordinates of the y-intercept. 2 marks

c. The point $\left(\sqrt{2}, \log_e(3)\right)$ lies on the graph of $y = f(x)$.

The graph of $y = f(x)$ has the following sequence of transformations applied:

1. a dilation by a factor of $\frac{1}{2}$ from the x-axis
2. a translation by 3 units in the positive direction of the x-axis

Find the coordinates of the image of the point $\left(\sqrt{2}, \log_e(3)\right)$ after the above transformations have been applied. 1 mark

Question 9 (9 marks)

Let $f : R \to R,\ f(x) = \dfrac{2 - e^{x}}{e^{2x}}$.

a. Show that $f'(x) = \dfrac{e^{x} - 4}{e^{2x}}$. 1 mark

b. The graph of $y = f(x)$ has exactly one stationary point.

i. Find the coordinates of this stationary point. 2 marks

ii. Determine the nature of this stationary point. 2 marks

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c. Find all values of x such that $f(x) \geq 0$. 1 mark

d. Given that $\int_p^q f(x)dx = 0$, where $p \neq q$ and $p,\ q \in R$, find an expression for p in terms of q. 3 marks

End of examination questions

End of examination. There are no more questions.

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End of examination. There are no more questions.

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Mathematical Methods
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Formula Sheet

You may keep this Formula Sheet.

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Mensuration

area of a trapezium	$\frac{1}{2}(a+b)h$	volume of a pyramid	$\frac{1}{3}Ah$
curved surface area of a cylinder	$2\pi rh$	volume of a sphere	$\frac{4}{3}\pi r^3$
volume of a cylinder	$\pi r^2 h$	area of a triangle	$\frac{1}{2}bc\sin(A)$
volume of a cone	$\frac{1}{3}\pi r^2 h$		

Calculus

$\frac{d}{dx}\left(x^n\right) = nx^{n-1}$	$\int x^n dx = \frac{1}{n+1}x^{n+1} + c,\ n \neq -1$
$\frac{d}{dx}\left((ax+b)^n\right) = an\left(ax+b\right)^{n-1}$	$\int (ax+b)^n dx = \frac{1}{a(n+1)}(ax+b)^{n+1} + c, n \neq -1$
$\frac{d}{dx}\left(e^{ax}\right) = ae^{ax}$	$\int e^{ax} dx = \frac{1}{a}e^{ax} + c$
$\frac{d}{dx}\left(\log_e(x)\right) = \frac{1}{x}$	$\int \frac{1}{x} dx = \log_e(x) + c,\ x > 0$
$\frac{d}{dx}\left(\sin(ax)\right) = a\cos(ax)$	$\int \sin(ax)dx = -\frac{1}{a}\cos(ax) + c$
$\frac{d}{dx}\left(\cos(ax)\right) = -a\sin(ax)$	$\int \cos(ax)dx = \frac{1}{a}\sin(ax) + c$
$\frac{d}{dx}\left(\tan(ax)\right) = \frac{a}{\cos^2(ax)} = a\sec^2(ax)$	

product rule	$\frac{d}{dx}(uv) = u\frac{dv}{dx} + v\frac{du}{dx}$	quotient rule	$\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$
chain rule	$\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx}$	Newton's method	$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$
trapezium rule approximation	$Area \approx \frac{x_n - x_0}{2n}\left[f(x_0) + 2f(x_1) + 2f(x_2) + \ldots + 2f(x_{n-2}) + 2f(x_{n-1}) + f(x_n)\right]$		

Probability

$\Pr(A) = 1 - \Pr(A')$		$\Pr(A \cup B) = \Pr(A) + \Pr(B) - \Pr(A \cap B)$	
$\Pr(A \mid B) = \dfrac{\Pr(A \cap B)}{\Pr(B)}$			
mean	$\mu = \mathrm{E}(X)$	variance	$\mathrm{var}(X) = \sigma^2 = \mathrm{E}((X-\mu)^2) = \mathrm{E}(X^2) - \mu^2$
binomial coefficient	$\binom{n}{x} = \dfrac{n!}{x!(n-x)!}$		

Probability distribution		**Mean**	**Variance**
discrete	$\Pr(X = x) = p(x)$	$\mu = \sum x\, p(x)$	$\sigma^2 = \sum (x-\mu)^2 p(x)$
binomial	$\Pr(X = x) = \binom{n}{x} p^x (1-p)^{n-x}$	$\mu = np$	$\sigma^2 = np(1-p)$
continuous	$\Pr(a < X < b) = \int_a^b f(x)\,dx$	$\mu = \int_{-\infty}^{\infty} x\, f(x)\,dx$	$\sigma^2 = \int_{-\infty}^{\infty} (x-\mu)^2 f(x)\,dx$

Sample proportions

$\hat{P} = \dfrac{X}{n}$		mean	$\mathrm{E}(\hat{P}) = p$
standard deviation	$\mathrm{sd}(\hat{P}) = \sqrt{\dfrac{p(1-p)}{n}}$	approximate confidence interval	$\left(\hat{p} - z\sqrt{\dfrac{\hat{p}(1-\hat{p})}{n}},\ \hat{p} + z\sqrt{\dfrac{\hat{p}(1-\hat{p})}{n}}\right)$

End of Formula Sheet

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