



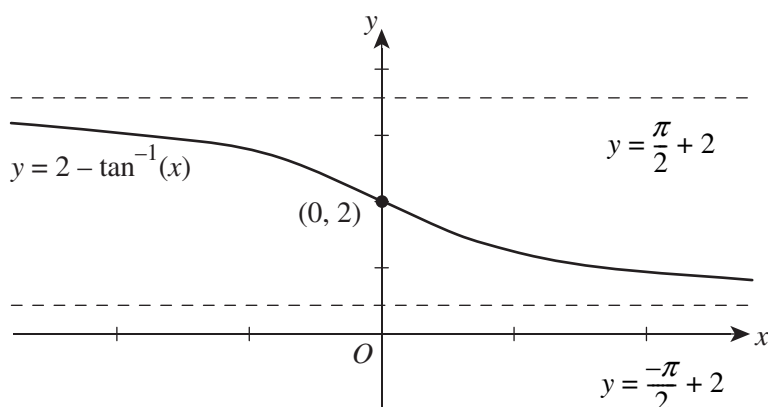
Trial Examination 2017

VCE Specialist Mathematics Units 3&4

Written Examination 1

Suggested Solutions

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Question 1 (3 marks)*correct shape* A1

The y-coordinate is (0, 2).

A1

The horizontal asymptotes are $y = \pm \frac{\pi}{2} + 2$.

A1

Question 2 (3 marks)The equations of motion are $T - 2g = 2a$ and $4g - T = 4a$.

A1

Attempting to solve for a and T ,

M1

$$a = \frac{g}{3} \text{ and } T = \frac{8g}{3}.$$

A1

Question 3 (4 marks)

$$\begin{aligned} \text{a. } \frac{1 + \tan^2(\theta)}{1 - \tan^2(\theta)} &= \frac{1 + \frac{\sin^2(\theta)}{\cos^2(\theta)}}{1 - \frac{\sin^2(\theta)}{\cos^2(\theta)}} \\ &= \frac{\cos^2(\theta) + \sin^2(\theta)}{\cos^2(\theta) - \sin^2(\theta)} \\ &= \frac{1}{\cos(2\theta)} \\ &= \sec(2\theta) \end{aligned}$$

M1

A1

b. Method 1:

$$\sec(2\theta) = 2 \Rightarrow \cos 2\theta = \frac{1}{2}$$

$$2\theta = \frac{\pi}{3}, \frac{5\pi}{3} \quad \text{M1}$$

$$\theta = \frac{\pi}{6}, \frac{5\pi}{6} \quad \text{A1}$$

Method 2:

$$1 + \tan^2(\theta) = 2(1 - \tan^2(\theta))$$

$$\tan(\theta) = \pm \frac{1}{\sqrt{3}} \quad \text{M1}$$

$$\theta = \frac{\pi}{6}, \frac{5\pi}{6} \quad \text{A1}$$

Question 4 (4 marks)

$$\text{a. } E(\bar{X}) = 30 \quad \text{A1}$$

$$\begin{aligned} \text{b. } \text{sd}(\bar{X}) &= \frac{\sigma}{\sqrt{n}} \\ &= \frac{7}{\sqrt{25}} \\ &= \frac{7}{5} \end{aligned} \quad \text{A1}$$

$$\text{c. } E(\bar{X}) = 30 \text{ (unchanged as it is independent of } n) \quad \text{A1}$$

$$\begin{aligned} \text{sd}(\bar{X}) &= \frac{\sigma}{\sqrt{n}} \\ &= \frac{7}{\sqrt{50}} \\ &= \frac{7}{5\sqrt{2}} \end{aligned}$$

$\text{sd}(\bar{X})$ is reduced by a factor of $\sqrt{2}$. A1

Question 5 (3 marks)

$$(a - bi)(x + yi) + (a + bi)(x - yi) = k \quad \text{M1}$$

$$(ax + by) + (ay - bx)i + (ax + by) + (bx - ay)i = k \quad \text{A1}$$

$$2ax + 2by = k \quad \text{A1}$$

Hence the equation $\bar{w}z + w\bar{z} = k$ represents a straight line.

Question 6 (5 marks)

a. Let $u = \frac{1}{x}$ and so $\frac{du}{dx} = -\frac{1}{x^2} = -u^2$. A1

$$x = 1 \Rightarrow u = 1 \text{ and } x = p \Rightarrow u = \frac{1}{p}$$

$$\int_1^p \frac{1}{1+x^2} dx = \int_1^{\frac{1}{p}} \frac{1}{1+\left(\frac{1}{u}\right)^2} \left(-\frac{1}{u^2}\right) du \quad \text{M1}$$

$$= -\int_1^{\frac{1}{p}} \frac{1}{u^2+1} du$$

$$= \int_{\frac{1}{p}}^1 \frac{1}{1+u^2} du \quad \text{A1}$$

b.
$$\int_1^p \frac{1}{1+x^2} dx = \int_{\frac{1}{p}}^1 \frac{1}{1+u^2} du$$

$$\left[\arctan(x) \right]_1^p = \left[\arctan(u) \right]_{\frac{1}{p}}^1 \quad \text{M1}$$

$$\arctan(p) - \arctan(1) = \arctan(1) - \arctan\left(\frac{1}{p}\right) \quad \text{A1}$$

$$\arctan(p) + \arctan\left(\frac{1}{p}\right) = 2\left(\frac{\pi}{4}\right) \text{ (or equivalent)}$$

$$\text{And so } \arctan(p) + \arctan\left(\frac{1}{p}\right) = \frac{\pi}{2}.$$

Question 7 (6 marks)

a. $P\left(\frac{i}{2}\right) = 0 \Rightarrow 2\left(\frac{i}{2}\right)^4 + bi\left(\frac{i}{2}\right)^3 + 2\left(\frac{i}{2}\right) + bi = 0 \quad \text{M1}$

$$\frac{1}{8} + \frac{b}{8} + i + bi = 0 \Rightarrow b = -1 \quad \text{A1}$$

b. $2z^4 - iz^3 + 2z - i = (2z - i)(z^3 + 1) = 0$

$$2z - i = 0 \Rightarrow z = \frac{i}{2} \text{ and so } z = \frac{1}{2} \operatorname{cis}\left(\frac{\pi}{2}\right) \quad \text{A1}$$

EITHER

$$z^3 + 1 = (z + 1)(z^2 - z + 1) = 0 \quad \text{M1}$$

$$\Rightarrow z = -1 \text{ or } z = \frac{1 \pm \sqrt{3}i}{2} \quad \text{A1}$$

OR

$$z^3 = -1 \quad \text{M1}$$

$$= \operatorname{cis}(\pi) \Rightarrow z = \operatorname{cis}\left(\frac{\pi + 2k\pi}{3}\right), k = 0, \pm 1 \quad \text{A1}$$

THEN

$$\Rightarrow z = \operatorname{cis}\left(-\frac{\pi}{3}\right), \operatorname{cis}\left(\frac{\pi}{3}\right), \operatorname{cis}(\pi) \quad \text{A1}$$

$$\text{So } z = \frac{1}{2} \operatorname{cis}\left(\frac{\pi}{2}\right), \operatorname{cis}\left(-\frac{\pi}{3}\right), \operatorname{cis}\left(\frac{\pi}{3}\right), \operatorname{cis}(\pi).$$

Question 8 (4 marks)

The denominator has an irreducible quadratic factor and a single linear factor. Hence there are two partial fractions.

$$\frac{x^2 + x}{(x^2 + 2)(x - 2)} = \frac{Ax + B}{x^2 + 2} + \frac{C}{x - 2}$$

$$x^2 + x = (Ax + B)(x - 2) + C(x^2 + 2)$$

A1

EITHER

Attempting to find the values of A , B and C .

M1

Substituting $x = 2$ gives:

$$6 = 6C \Rightarrow C = 1$$

Substituting $x = 0$ for example with $C = 1$ gives:

$$0 = -2B + 2 \Rightarrow B = 1$$

Substituting $x = 1$ for example with $B = 1$ and $C = 1$ gives:

$$2 = -1 - A + 3 \Rightarrow A = 0$$

So $A = 0$, $B = 1$ and $C = 1$.

OR

$$x^2 + x = (A + C)x^2 + (-2A + B)x + (-2B + 2C)$$

Attempting to equate coefficients:

M1

$$A + C = 1$$

$$-2A + B = 1$$

$$-2B + 2C = 0$$

Solving gives $A = 0$, $B = 1$ and $C = 1$.

THEN

$$\begin{aligned} \int \frac{x^2 + x}{(x^2 + 2)(x - 2)} dx &= \int \left(\frac{1}{x^2 + 2} + \frac{1}{x - 2} \right) dx \\ &= \frac{1}{\sqrt{2}} \tan^{-1} \left(\frac{x}{\sqrt{2}} \right) + \log_e |x - 2| + c \end{aligned}$$

M1 A1

Question 9 (3 marks)

$$(\underline{a} \cdot \underline{b})^2 = |\underline{a}|^2 |\underline{b}|^2 \cos^2(\theta)$$

A1

$$\leq |\underline{a}|^2 |\underline{b}|^2 \text{ since } 0 \leq \cos^2(\theta) \leq 1$$

A1

$$(\underline{a} \cdot \underline{b})^2 = (a_1 b_1 + a_2 b_2 + a_3 b_3)^2, |\underline{a}|^2 = a_1^2 + a_2^2 + a_3^2 \text{ and } |\underline{b}|^2 = b_1^2 + b_2^2 + b_3^2 \text{ leading to}$$

$$(a_1 b_1 + a_2 b_2 + a_3 b_3)^2 \leq (a_1^2 + a_2^2 + a_3^2)(b_1^2 + b_2^2 + b_3^2)$$

A1

Question 10 (5 marks)

$$\begin{aligned}\frac{dx}{dt} &= \frac{-2t(1+t^2) - 2t(1-t^2)}{(1+t^2)^2} \\ &= \frac{-4t}{(1+t^2)^2}\end{aligned}$$

A1

$$\begin{aligned}\frac{dy}{dt} &= \frac{4(1+t^2) - 2t(4t)}{(1+t^2)^2} \\ &= \frac{4-4t^2}{(1+t^2)^2}\end{aligned}$$

A1

$$\begin{aligned}\frac{dy}{dx} &= \left(\frac{4-4t^2}{(1+t^2)^2} \right) \left(-\frac{(1+t^2)^2}{4t} \right) \\ &= \frac{t^2-1}{t}\end{aligned}$$

M1

At $t = \frac{1}{2}$, $x = \frac{3}{5}$, $y = \frac{8}{5}$ and $\frac{dy}{dx} = -\frac{3}{2}$.

M1

The equation of the tangent is $y - \frac{8}{5} = -\frac{3}{2}\left(x - \frac{3}{5}\right)$ (or equivalent).

A1