Section A

1. (a) Let N be North

$\text{N}\hat{\text{J}}\text{D} = 34°$ OR $\text{D}\hat{\text{J}}\text{L} = 56°$ (must be labelled or indicated in diagram): ***(A1)***

$\text{J}\hat{\text{D}}\text{L} = 99\,(°)$ ***A1***

Note: Accept $\frac{11\pi}{20}, 1.73$ (radians).

[2 marks]

(b) attempt to apply the sine rule ***(M1)***

$\frac{\text{DL}}{\sin 56°} = \frac{500}{\sin 99°}$ OR $\frac{\text{DL}}{\sin 0.977384...} = \frac{500}{\sin 1.72787...}$ ***(A1)***

$419.685...$

$\text{DL} = 420$ (km) ***A1***

Note: Award ***M1A1A0*** for 261 (km) from use of degrees with GDC set in radians (with or without working).

[3 marks]

Total [5 marks]

2. (a) 9% (accept 0.09) ***A1***

[1 mark]

(b) $t = 5$ (seen anywhere) ***(A1)***

$24961.28...$

25000 (dollars) ***A1***

[2 marks]

continued…

Question 2 continued

(c) **EITHER**

$n = 5$

$\text{I\%} = 3$

$\text{PV} = (\mp)15000$

$\text{P/Y} = 1$

$\text{C/Y} = 1$ ***(A1)***

Note: Award ***(A1)*** for use of a financial app in their technology with all entries correct.

$(\Rightarrow \text{FV} = (\pm)17389.11...)$

OR

$15\,000\left(1+\frac{3}{100}\right)^5 \ (=17389.11...)$ ***(A1)***

THEN

subtracting their value from their answer to part (b) ***(M1)***

$7572.17\ldots$

7570 (dollars) ***A1***

[3 marks]

Total [6 marks]

3. (a) attempt to substitute g into f ***(M1)***

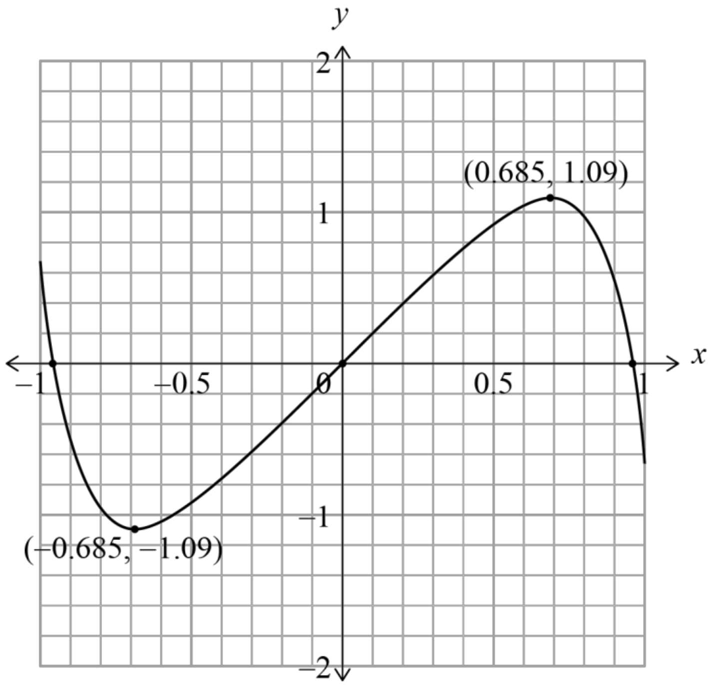
$(f \circ g)(x) = 2\tan x - \tan^3 x$ ***A1***

[2 marks]

continued…

Question 3 continued

(b)



A1A1A1

Note: ***A1*** for approximately correct odd function passing through the origin with a maximum above $y = 1$ and a minimum below $y = -1$.

A1 for endpoints at $x = \pm 1$ and y in the intervals $[0.6, 0.8]$ and $[-0.8, -0.6]$

A1 for maximum in approximately correct position and labelled $(0.685, 1.09)$ AND minimum in approximately correct position and labelled $(-0.685, -1.09)$. For approximate position, allow $-0.8 \le x \le -0.6$, $-1.2 \le y \le -1$ for minimum and $0.6 \le x \le 0.8$, $1 \le y \le 1.2$ for maximum. If the candidate gives the coordinates of extrema below their sketch, only award this mark if extrema are marked in the correct interval (eg by a dot).

[3 marks]

Total [5 marks]

4. (a) recognising to find $y(25)$ ***(M1)***

$y(25) = -0.6 \times 25^2 + 23 \times 25 + 110$

$= 310$ (children) ***A1***

[2 marks]

(b) recognizing x on y is required ***(M1)***

$0.0935114\ldots$ and $7.43053\ldots$ ***(A1)***

$x = 0.0935y + 7.43$ ***A1***

[3 marks]

continued…

Question 4 continued

(c) attempt to substitute their answer to part (a) into their regression equation for either x or y ***(M1)***

$x = 0.0935114... \times 310 + 7.43053... (= 36.4190...)$

36 (accept 37 or 36.4) ***A1***

Note: Award ***(M1)A1FT*** for $x = 37$ found from using $y = 9.39x - 41.5$. Award ***(M1)A0FT*** for a correct ***FT*** answer that lies outside $[15, 46]$.

[2 marks]

Total [7 marks]

Section A

1. (a) $a = 1.93258...$, $b = 7.21662...$

$a = 1.93$, $b = 7.22$ ***A1A1***

[2 marks]

(b) $r = 0.991087...$

$r = 0.991$ ***A1***

[1 mark]

(c) attempt to substitute $d = 20$ into their equation ***(M1)***

$\text{height} = 45.8683...$

$\text{height} = 45.9$ (cm) ***A1***

[2 marks]

Total [5 marks]

3. (a) $A(0) = 500$ (mg) ***A1***

[1 mark]

(b) $280 = 500\mathrm{e}^{-3k}$ ***(A1)***

$k = 0.193272...$

$k = 0.193 \ \left(= -\frac{1}{3}\ln\left(\frac{280}{500}\right)\right)$ ***A1***

[2 marks]

(c) $500\mathrm{e}^{-0.193272...T} = 140$ ***(A1)***

$T = 6.58636...$

$T = 6.59$ (h) ***A1***

[2 marks]

Total [5 marks]

Section B

7. (a) (i) $96\,(°)$ (exact) ***A1***

(ii) $79.9970...$

$80.0\,(°)$ (accept 80) ***A1***

[2 marks]

(b) $-4.71976...$

-4.72 (°C min^{-1}) ***A2***

[2 mark]

(c) 3 valid descriptors, in any order: ***A2***

- at 3 minutes (or when $t = 3$)
- cooling/decreasing (do not accept "changing")
- 4.72 °C min^{-1} (must include units) (accept approximately 5 deg/min)

[2 marks]

continued…

Question 7 continued

(d) **METHOD 1**

valid attempt to solve $H(t) = 67$ (accept an inequality) ***(M1)***

eg intersection of graphs, use of logarithms.

6.11058… ***(A1)***

7 (min) ***A1***

METHOD 2

valid attempt to find crossover values ***(M1)***

(6, 67.4087…) and (7, 63.8406…) ***(A1)***

7 (min) ***A1***

[3 marks]

(e) recognition that $t \to \infty$ ***(M1)***

$21(°C)$ ***A1***

[2 marks]

(f) **METHOD 1 (working with slopes of *H*)**

valid attempt to analyse progression of slopes of *H* ***(M1)***

$\lim\limits_{t\to\infty} H'(t) = 0$ ***A1***

METHOD 2 (working with H')

valid attempt to use H' and large values of t. ***(M1)***

$\lim\limits_{t\to\infty} H'(t) = 0$ ***A1***

[2 marks]

Total [13 marks]

Section B

7. (a) (i) swapping x and y, or $h\left(h^{-1}(x)\right)=x$ ***(M1)***

$h^{-1}(x)=\frac{x^2+2}{4}$ ***A1***

recognizing range of h is domain of h^{-1} ***(M1)***

Domain: $x \geq 0$ ***A1***

(ii) range of h^{-1} is $y \geq \frac{1}{2}$ ***A1***

[5 marks]

(b) $\sqrt{4x-2}=\frac{x^2+2}{4}$ OR $\sqrt{4x-2}=x$ OR $\frac{x^2+2}{4}=x$ ***(M1)***

$x=0.585786...$, $x=3.414213...\left(=2+\sqrt{2}\right)$

$x=0.586$, $x=3.41$ ***A1A1***

[3 marks]

(c) attempt to form integral of the difference between $h(x)$ and their h^{-1}, using their limits from part (b) ***(M1)***

$\int_{0.585786...}^{3.414213...}\left(h(x)-h^{-1}(x)\right)\mathrm{d}x$ OR $\int_{0.585786...}^{3.414213...}\left(\sqrt{4x-2}-\frac{x^2+2}{4}\right)\mathrm{d}x$ OR

$6.5996632...-4.7140452...$

$1.88561...$

$\text{area}=1.89$ ***A1***

[2 marks]

continued…

Question 7 continued

(d) attempt to use chain rule or power rule ***(M1)***

$$h'(x) = 4 \cdot \frac{1}{2}(4x-2)^{-\frac{1}{2}}$$

$$h'(x) = \frac{2}{\sqrt{4x-2}}$$ ***A1***

[2 marks]

(e) **EITHER**

$$\left(h^{-1}\right)'(x) = \frac{x}{2}$$ ***(A1)***

equating their $h'(x)$ to the derivative of their $h^{-1}(x)$ and attempting to solve for x ***(M1)***

$$\frac{2}{\sqrt{4x-2}} = \frac{x}{2}$$

OR

finding intersection of graphs of their derivatives ***(M2)***

THEN

$1.772776...$

$x = 1.77$ ***A1***

[3 marks]

Total [15 marks]

9. (a) recognition that $45 = 10 + 10 + \text{arc length}$ ***(M1)***

arc length $= 25\ \text{(cm)}$ ***(A1)***

$25 = 12\theta$ ***A1***

$\theta = 2.08$ correct to 3 significant figures ***AG***

[3 marks]

continued…

Question 9 continued

(b)

Note: There are many different ways to dissect the cross-section to determine its area. In all approaches, candidates will need to find w or $\frac{w}{2}$. Award the first three marks for work seen anywhere.

EITHER

evidence of using the cosine rule OR sine rule ***(M1)***

$w^2 = 12^2 + 12^2 - 2 \cdot 12 \cdot 12 \cos(2.08)$ OR $\frac{w}{\sin(2.08)} = \frac{12}{\sin(0.530796...)}$ ***(A1)***

$w = 20.6977\ldots$ or $\frac{w}{2} = 10.3488...$ ***(A1)***

OR

using trig ratios in a right triangle with angle $\frac{2.08}{2}$ and side length $\frac{w}{2}$ ***(M1)***

$\sin\left(\frac{2.08}{2}\right) = \frac{\frac{w}{2}}{12}$ ***(A1)***

$w = 20.6977\ldots$ or $\frac{w}{2} = 10.3488...$ ***(A1)***

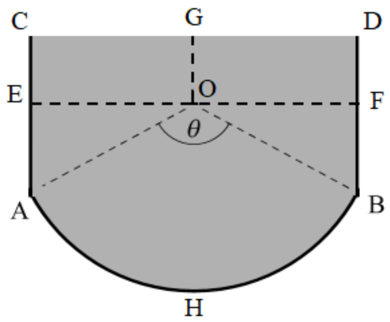
Note: Accept $w = 20.7179\ldots$ from use of $\frac{\theta}{2} = \frac{25}{24}$.

continued…

Question 9 continued

THEN

Let the points A, B, C, D, E, F, G, H lie on the figure as follows:



EITHER

(segment AHB =) sector OAB – triangle OAB ***(M1)***

= $\frac{1}{2}\times 12^2\times 2.08-\frac{1}{2}\times 12^2\times\sin 2.08\left(=149.76-62.8655...=86.8944...\right)$ ***(A1)***

valid approach to find total cross-sectional area (seen anywhere) ***(M1)***

sector OAB – triangle OAB + rectangle CDBA

= $86.8944...+10w\left(=86.8944...+206.977...\right)$

> **Note:** Use of $\theta=\frac{25}{12}$ throughout leads to segment OAB $=87.2517...$ and cross-sectional area $=87.2517...+207.179...$.

continued…

Question 9 continued

OR

trapezium CGOA (= rectangle CGOE + triangle EOA) ***(M1)***

$=\frac{1}{2}\times\left(10+\left(10-12\cos(1.04)\right)\right)\times\frac{20.6977...}{2}\ \ (=72.0557)$ ***(A1)***

valid approach to find total cross-sectional area (seen anywhere) ***(M1)***

2 × trapezium CGOA + sector OAB

= $2(72.0557...)+\frac{1}{2}\times12^2\times2.08\left(=144.111...+149.76\right)$

Note: Use of $\theta=\frac{25}{12}$ leads to area of trapezium CGOA $=72.2154...$ and cross-sectional area $=144.430...+150$.

OR

2 x area of trapezium CGOA (= area of rectangle CDFE + 2 x triangle EOA) ***(M1)***

$20.6977...\times\left(10-12\cos(1.04)\right)+2\times\frac{1}{2}\times12\cos(1.04)\times12\sin(1.04)$ ***(A1)***

$\left(=81.2458...+62.8655...\right)$

valid approach to find total cross-sectional area (seen anywhere) ***(M1)***

2 x trapezium CGOA + sector OAB

$=144.111...+\frac{1}{2}\times12^2\times2.08\ \ \left(=144.111...+149.76\right)$

Note: Use of $\theta=\frac{25}{12}$ leads to 2 x area of trapezium CGOA $=144.430...$ and cross-sectional area $=144.430...+150$.

continued…

Question 9 continued

THEN

area of cross-section $= 293.871...$ ($294.430...$ from exact answer)

$= 294$ (cm^2) ***A1***

[7 marks]

continued…

Question 9 continued

(c) **METHOD 1**

volume of gutter $=176323$ OR 176658 (OR $600\times$ their area) (seen anywhere) ***A1***

recognising rainfall can be represented by an integral ***(M1)***

$\int_0^{60} R'(t)\,\mathrm{d}t\left(=\frac{250}{2\pi}\sin\left(\frac{2\pi\times 60}{5}\right)+3000\times 60\right)$ ***(A1)***

Note:	Accept any 60 second interval or any interval which is a multiple of 5 seconds (one period) scaled up to 60 seconds e.g. $12\int_0^5 R'(t)\,\mathrm{d}t$.

rainfall over 60 seconds $=180000$ (cm^3) ***A1***

the gutter will overflow because the rainfall > gutter volume ***A1***

METHOD 2

volume of gutter $=176323$ OR 176658 (OR $600\times$ their area) (seen anywhere) ***A1***

recognition that cosine has a minimum value of -1 ***(M1)***

$R'(t)\geq -1\times 50+3000\left(\mathrm{cm}^3\mathrm{s}^{-1}\right)$ ***(A1)***

rainfall over 60 seconds ≥ 177000 ***(A1)***

the gutter will overflow because the rainfall > gutter volume ***A1***

continued…

Question 9 continued

METHOD 3

volume of gutter $=176323$ OR 176658 (OR $600\times$ their area) (seen anywhere) ***A1***

recognising rainfall can be represented by an integral ***(M1)***

attempt to solve $60>58.8$ OR $\int_0^T R'(t)\,\mathrm{d}t=176658$ ***(M1)***

time to reach overflow point = $58.7875...$ OR $58.8990...$ ***A1***

the gutter will overflow because $60>58.8$ OR $60>58.9$ ***A1***

[5 marks]

Total [15 marks]