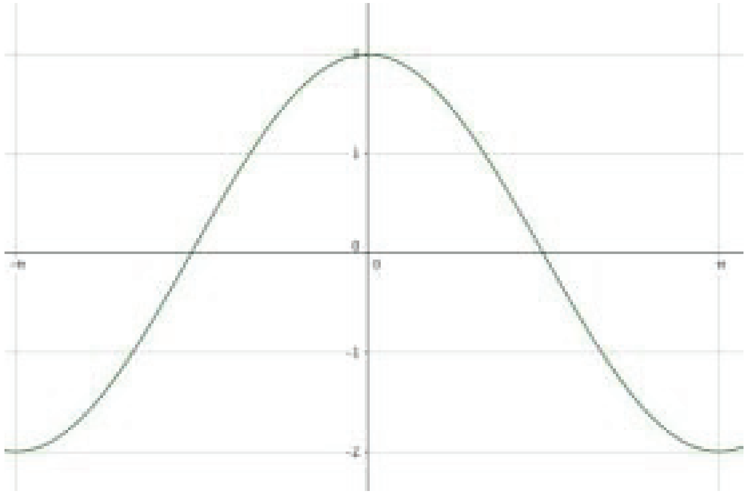
Question	Answer	Marks	Guidance
1	$(3-2x)^6$		
	Coeff of $x^2 = 3^4 \times (-2)^2 \times {}_6C_2 = a$ Coeff of $x^3 = 3^3 \times (-2)^3 \times {}_6C_3 = b$	**B3,2,1**	Mark unsimplified forms. –1 each independent error but powers must be correct. Ignore any 'x' present.
	$\frac{a}{b} = -\frac{9}{8}$	**B1**	OE. Negative sign must appear before or in the numerator
	Total:	**4**	
2	$\overrightarrow{OA} = \begin{pmatrix} 3 \\ -6 \\ p \end{pmatrix}$ and $\overrightarrow{OB} = \begin{pmatrix} 2 \\ -6 \\ -7 \end{pmatrix}$		
2(i)	Angle $AOB = 90° \rightarrow 6 + 36 - 7p = 0$	**M1**	Use of $x_1x_2 + y_1y_2 + z_1z_2 = 0$ or Pythagoras
	$\rightarrow p = 6$	**A1**	
	Total:	**2**	

Question	Answer	Marks	Guidance
2(ii)	$\overrightarrow{OC} = \frac{2}{3}\begin{pmatrix} 3 \\ -6 \\ p \end{pmatrix} = \begin{pmatrix} 2 \\ -4 \\ 4 \end{pmatrix}$	**B1 FT**	CAO FT on their value of p
	$\overrightarrow{BC} = \mathbf{c} - \mathbf{b} = \begin{pmatrix} 0 \\ 2 \\ 11 \end{pmatrix}$; magnitude = $\sqrt{125}$	**M1 M1**	Use of **c** – **b**. Allow magnitude of **b** + **c** or **b** – **c** Allow first **M1** in terms of p
	Unit vector = $\frac{1}{\sqrt{125}}\begin{pmatrix} 0 \\ 2 \\ 11 \end{pmatrix}$	**A1**	OE Allow ± and decimal equivalent
3(i)	$\frac{1+\cos\theta}{\sin\theta} + \frac{\sin\theta}{1+\cos\theta} \equiv \frac{2}{\sin\theta}$.		
	$\frac{(1+c)^2 + s^2}{s(1+c)} = \frac{1+2c+c^2+s^2}{s(1+c)}$	**M1**	Correct use of fractions
	$= \frac{2+2c}{s(1+c)} = \frac{2(1+c)}{s(1+c)} \to \frac{2}{s}$	**M1 A1**	Use of trig identity, **A1** needs evidence of cancelling
	Total:	**3**	
3(ii)	$\frac{2}{s} = \frac{3}{c} \to t = \frac{2}{3}$	**M1**	Use part **(i)** and $t = s \div c$, may restart from given equation
	$\to \theta = 33.7°$ or $213.7°$	**A1 A1FT**	FT for 180° + 1st answer. 2nd **A1** lost for extra solns in range
	Total:	**3**	

Question	Answer	Marks	Guidance
4(a)	$a = 32$, $a + 4d = 22$, $\rightarrow d = -2.5$	**B1**	
	$a + (n-1)d = -28 \rightarrow n = 25$	**B1**	
	$S_{25} = \frac{25}{2}\left(64 - 2.5\times 24\right) = 50$	**M1 A1**	**M1** for correct formula with $n = 24$ or $n = 25$
	Total:	**4**	
4(b)	$a = 2000$, $r = 1.025$	**B1**	$r = 1 + 2.5\%$ ok if used correctly in S_n formula
	$S_{10} = 2000\left(\frac{1.025^{10} - 1}{1.025 - 1}\right) = 22400$ or a value which rounds to this	**M1 A1**	**M1** for correct formula with $n = 9$ or $n = 10$ and their a and r
			SR: correct answer only for $n = 10$ **B3**, for $n = 9$, **B1** (£19 900)
	Total:	**3**	

Question	Answer	Marks	Guidance
5	$y = 2\cos x$		
5(i)		B1	One whole cycle – starts and finishes at –ve value
		DB1	Smooth curve, flattens at ends and middle. Shows (0, 2).
	Total:	**2**	
5(ii)	$P(\frac{\pi}{3}, 1)\ Q(\pi, -2)$		
	$\rightarrow PQ^2 = \left(\frac{2\pi}{3}\right)^2 + 3^2 \rightarrow PQ = 3.7$	M1 A1	Pythagoras (on their coordinates) must be correct, OE.
	Total:	**2**	

Question	Answer	Marks	Guidance
5(iii)	Eqn of PQ $y-1=-\frac{9}{2\pi}\left(x-\frac{\pi}{3}\right)$	**M1**	Correct form of line equation or sim equations from their P & Q
	If $y=0 \rightarrow h=\frac{5\pi}{9}$	**A1**	AG, condone $x=\frac{5\pi}{9}$
	If $x=0 \rightarrow k=\frac{5}{2}$,	**A1**	SR: non-exact solutions **A1** for both
	Total:	**3**	
6(i)	Volume = $\left(\frac{1}{2}\right)x^2\frac{\sqrt{3}}{2}h=2000 \rightarrow h=\frac{8000}{\sqrt{3}x^2}$	**M1**	Use of (area of triangle, with attempt at ht) × h =2000, $h=\text{f}(x)$
	$A=3xh+(2)\times\left(\frac{1}{2}\right)\times x^2\times\frac{\sqrt{3}}{2}$	**M1**	Uses 3 rectangles and at least one triangle
	Sub for $h \rightarrow A=\frac{\sqrt{3}}{2}x^2+\frac{24000}{\sqrt{3}}x^{-1}$	**A1**	AG
	Total:	**3**	
6(ii)	$\frac{\text{d}A}{\text{d}x}=\frac{\sqrt{3}}{2}2x-\frac{24000}{\sqrt{3}}x^{-2}$	**B1**	CAO, allow decimal equivalent
	= 0 when $x^3=8000 \rightarrow x=20$	**M1 A1**	Sets their $\frac{\text{d}A}{\text{d}x}$ to 0 and attempt to solve for x
	Total:	**3**	

Question	Answer	Marks	Guidance
6(iii)	$\frac{d^2A}{dx^2} = \frac{\sqrt{3}}{2}2 + \frac{48000}{\sqrt{3}}x^{-3} > 0$	M1	Any valid method, ignore value of $\frac{d^2A}{dx^2}$ providing it is positive
	→ Minimum	A1 FT	FT on their x providing it is positive
	Total:	**2**	
7	$\frac{dy}{dx} = 7 - x^2 - 6x$		
7(i)	$y = 7x - \frac{x^3}{3} - \frac{6x^2}{2}$ $(+ c)$	B1	CAO
	Uses $(3, -10) \rightarrow c = 5$	M1 A1	Uses the given point to find c
	Total:	**3**	
7(ii)	$7 - x^2 - 6x = 16 - (x+3)^2$	B1 B1	**B1** $a = 16$, **B1** $b = 3$.
	Total:	**2**	
7(iii)	$16 - (x+3)^2 > 0 \rightarrow (x + 3)^2 < 16$, and solve	M1	or factors $(x + 7)(x - 1)$
	End-points $x = 1$ or -7	A1	
	$\rightarrow -7 < x < 1$	A1	needs $<$, not $\leqslant$. (SR $x < 1$ only, or $x > -7$ only **B1** i.e. 1/3)
	Total:	**3**	

Question	Answer	Marks	Guidance
8(i)	Letting M be midpoint of AB		
	$OM = 8$ (Pythagoras) → $XM = 2$	**B1**	(could find √40 and use $\sin^{-1}$ or $\cos^{-1}$)
	$\tan AXM = \frac{6}{2}$ $AXB = 2\tan^{-1}3 = 2.498$	**M1 A1**	AG Needs × 2 and correct trig for **M1**
	(Alternative 1: $\sin AOM = \frac{6}{10}, AOM = 0.6435, AXB = \pi - 0.6435$)		(Alternative 1: Use of isosceles triangles, **B1** for AOM, **M1**,**A1** for completion) (Alternative 2: Use of circle theorem, **B1** for AOB, **M1**,**A1** for completion)
	Total:	**3**	
8(ii)	$AX = \sqrt{(6^2 + 2^2)} = \sqrt{40}$	**B1**	CAO, could be gained in part (i) or part (iii)
	Arc $AYB = r\theta = \sqrt{40} \times 2.498$	**M1**	Allow for incorrect √40 (not $r = 6\, or\, 12\, or\, 10$)
	Perimeter = 12 + arc = 27.8 cm	**A1**	
	Total:	**3**	
8(iii)	area of sector $AXBY = \frac{1}{2} \times (\sqrt{40})^2 \times 2.498$	**M1**	Use of $\frac{1}{2}r^2\theta$ with their r, (not $r = 6\, or\, r = 10$)
	Area of triangle $AXB = \frac{1}{2} \times 12 \times 2$, Subtract these → 38.0 cm²	**M1 A1**	Use of $\frac{1}{2}bh$ and subtraction. Could gain **M1** with $r = 10$.
	Total:	**3**	

Question	Answer	Marks	Guidance
9	$f : x \mapsto \frac{2}{3-2x}$ $g : x \mapsto 4x + a,$		
9(i)	$y = \frac{2}{3-2x} \rightarrow y(3-2x) = 2 \rightarrow 3-2x = \frac{2}{y}$	M1	Correct first 2 steps
	$\rightarrow 2x = 3 - \frac{2}{y} \rightarrow f^{-1}(x) = \frac{3}{2} - \frac{1}{x}$	M1 A1	Correct order of operations, any correct form with $f(x)$ *or* $y =$
	Total:	3	
9(ii)	$gf(-1) = 3$ $f(-1) = \frac{2}{5}$	M1	Correct first step
	$\frac{8}{5} + a = 3 \rightarrow a = \frac{7}{5}$	M1 A1	Forms an equation in a and finds a, OE
			(or $\frac{8}{3-2x} + a = 3$, **M1** Sub and solves **M1**, **A1**)
	Total:	3	
9(iii)	$g^{-1}(x) = \frac{x-a}{4} = f^{-1}(x)$	M1	Finding $g^{-1}(x)$ and equating to their $f^{-1}(x)$ even if $a = 7/5$
	$\rightarrow x^2 - x(a+6) + 4 (= 0)$	M1	Use of $b^2 - 4ac$ on a quadratic with a in a coefficient
	Solving $(a+6)^2 = 16$ *or* $a^2 + 12a + 20 (= 0)$	M1	Solution of a 3 term quadratic
	$\rightarrow a = -2$ or -10	A1	
	Total:	4	

Question	Answer	Marks	Guidance
10(i)	$\frac{dy}{dx} = \frac{-4}{(5-3x)^2} \times (-3)$	B1 B1	**B1** without ×(−3) **B1** For ×(−3)
	Gradient of tangent = 3, Gradient of normal – ⅓	*M1	Use of $m_1 m_2 = -1$ after calculus
	→ eqn: $y - 2 = -\frac{1}{3}(x-1)$	DM1	Correct form of equation, with (1, their y), not (1,0)
	→ $y = -\frac{1}{3}x + \frac{7}{3}$	A1	This mark needs to have come from $y = 2$, y must be subject
	Total:	**5**	
10(ii)	Vol = $\pi \int_0^1 \frac{16}{(5-3x)^2} dx$	M1	Use of $V = \pi \int y^2 dx$ with an attempt at integration
	$\pi\left[\frac{-16}{(5-3x)} \quad \div -3\right]$	A1 A1	**A1** without(÷ −3), **A1** for (÷ −3)
	= ($\pi\left(\frac{16}{6} - \frac{16}{15}\right)$) = $\frac{8\pi}{5}$ (if limits switched must show – to +)	M1 A1	Use of both correct limits **M1**
	Total:	**5**	