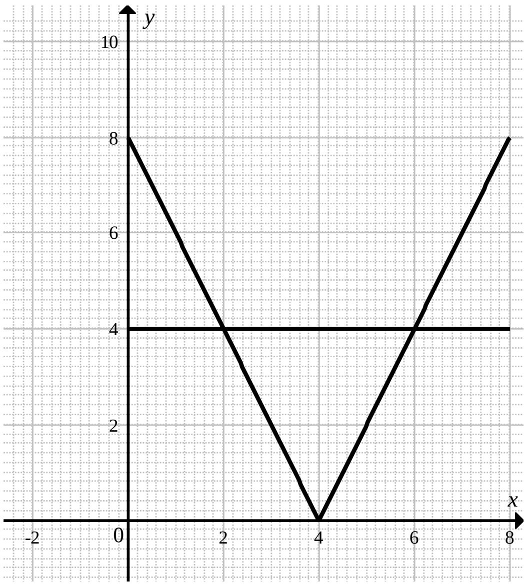
Question	Answer	Marks	Partial marks
1	Correct elimination of one unknown e.g. $\left(\frac{3}{2}\right)^4 \times \frac{1}{x} = \frac{27}{16}$ or $\left(\frac{3}{2}x\right)^4 \times \frac{1}{x^5} = \frac{27}{16}$ or $\frac{y^4}{\left(\frac{2y}{3}\right)^5} = \frac{27}{16}$ or $16\left(\frac{81}{16}x^4\right) = 27x^5$ or $16y^4 = 27\left(\frac{32}{243}y^5\right)$ oe	**M1**	
	$x = 3$ and $y = \frac{9}{2}$ oe and no other solutions	**A2**	**A1** for $x = 3$ or $y = \frac{9}{2}$ oe
2(a)	$\frac{d}{dx}\sqrt{1+2x} = (1+2x)^{-\frac{1}{2}}$ or $\frac{1}{2}\times(1+2x)^{-\frac{1}{2}}\times 2$ oe	**B2**	**B1** for $k(1+2x)^{-\frac{1}{2}}$ where k is a positive constant, $k \neq 1$
	$x \times \textit{their}\left(\frac{1}{2}(1+2x)^{-\frac{1}{2}}\times 2\right) + [1](1+2x)^{\frac{1}{2}}$ oe, isw	**B1**	**FT** *their* $\frac{d}{dx}\sqrt{1+2x}$
	Alternative		
	$\frac{1}{2}\left(x^2+2x^3\right)^{-\frac{1}{2}}\times\left(2x+6x^2\right)$ or $\frac{1}{2}\left(x^2(1+2x)\right)^{-\frac{1}{2}}\times\left(2x^2+2x(1+2x)\right)$	**(B3)**	**B2** for $\frac{1}{2}\left(x^2+2x^3\right)^{-\frac{1}{2}}\times\left(ax+bx^2\right)$ or $\frac{1}{2}\left(x^2(1+2x)\right)^{-\frac{1}{2}}\times\left(ax+bx^2\right)$ where a and b are constants or **B1** for $k\left(x^2+2x^3\right)^{-\frac{1}{2}}$ or $k\left(x^2(1+2x)\right)^{-\frac{1}{2}}$ where k is a positive constant, soi
2(b)	Uses *their* $4(1+2(4))^{-\frac{1}{2}} + (1+2(4))^{\frac{1}{2}}$ in an attempt at a small changes relationship	**M1**	**FT** $x = 4$ substituted into *their* derivative
	$\frac{0.06}{\delta x} = \textit{their}\left(4(1+2(4))^{-\frac{1}{2}} + (1+2(4))^{\frac{1}{2}}\right)$ oe	**M1**	**dep** previous **M1** **FT** *their* $\frac{13}{3}$
	0.0138 or 0.01384[6…] or $\frac{9}{650}$ oe nfww	**A1**	

Question	Answer	Marks	Partial marks
2(c)	$\dfrac{x}{\sqrt{1+2x}}+\sqrt{1+2x}=0$ oe and solves as far as $x=$ ….	**M1**	**FT** a derivative of the form $\dfrac{ax}{\sqrt{1+2x}}+b\sqrt{1+2x}$ or $\dfrac{a}{\sqrt{1+2x}}+b\sqrt{1+2x}$ or $\dfrac{ax+b}{\sqrt{1+2x}}$ oe
	$x=-\dfrac{1}{3}$ oe	**A1**	
3(a)	$8a-12-6+b=0$ oe and $-a-3+3+b=0$ oe and $a=2$, $b=2$	**B3**	**B1** for $8a-12-6+b=0$ oe **B1** for $-a-3+3+b=0$ oe
3(b)	$[2x^3-3x^2-3x+2=]$ $(x-2)$, $(x+1)$, $(2x-1)$ or (x^2-x-2), $(2x-1)$ **and** $x=2$, $\frac{1}{2}$, -1 OR $[2x^3-3x^2-3x+2=]$ $(x+1)$, $(2x^2-5x+2)$ or $(x-2)$, $(2x^2+x-1)$ **and** correct factorisation or method of solution of the quadratic **and** $x=2$, $\frac{1}{2}$, -1 OR $2-1+x=-\left(\dfrac{-3}{2}\right)$ or $2-1+x=\dfrac{3}{2}$ or for $2\times-1\times x=\dfrac{-2}{2}$ or $2\times-1\times x=-1$ **and** $x=2$, $\frac{1}{2}$, -1	**B2**	**B1** for $[2x^3-3x^2-3x+2=]$ $(x-2)$ and $(x+1)$ seen or (x^2-x-2) seen or $(x+1)$, $(2x^2-5x+2)$ or $(x-2)$, $(2x^2+x-1)$ **B1** for $2-1+x=-\left(\dfrac{-3}{2}\right)$ or $\dfrac{3}{2}$ or for $2\times-1\times x=\dfrac{-2}{2}$ or -1

Question	Answer	Marks	Partial marks
4	Correct intersecting graphs 	**3**	$y = \|2x - 8\|$: **M1** for an attempt to draw the sections from (0, 8) to (2, 4) and (6, 4) to (8, 8) with at least one side accurate or for ∨ shape with vertex at (4, 0) **A1** for correct graph **B1** for $y = 4$ drawn
	critical values: 2, 6	**M1**	**dep** on 3 marks awarded for intersecting graphs
	$x < 2$, $x > 6$ mark final answer	**A1**	
5(a)	Correctly derives correct equation free of logarithms e.g. $x^9 = 16^{18}$ or $x = 16^2$ oe or $x^9 = 2^{72}$ or $x = 2^8$ oe or $x^{\frac{9}{4}} = 2^{18}$ oe	**M3**	**M2** for correctly changing to consistent bases **and** correct use of one other log law or correct use of $\log_a a = 1$ in a correct equation e.g. $\dfrac{\log_{16} x^2}{\frac{1}{4}} + \log_{16} x = 18$ oe or $\log_2 x^2 + \dfrac{\log_2 x}{4} = 18$ oe or $\dfrac{\log_x x^2}{\log_x 2} + \dfrac{\log_x x}{4\log_x 2} = 18$ or **M1** for correctly changing to consistent bases or correct use of one other log law or correct use of $\log_a a = 1$ in a correct equation
	$x = 256$ nfww	**A1**	

Question	Answer	Marks	Partial marks
5(b)	$e^{4x+2} - 3e^{2x+1} - 10$ [= 0] or $\left(e^{2x+1}\right)^2 - 3e^{2x+1} - 10$ [= 0]	**B1**	
	Solves or factorises *their* 3-term quadratic in e^{2x+1}	**M1**	**FT** *their* 3-term quadratic in e^{2x+1}
	$e^{2x+1} = 5$ nfww	**A1**	
	$x = \dfrac{-1+\ln 5}{2}$ oe, isw or 0.305 or 0.3047[18…] isw	**A1**	and no other solution
	Alternative		
	$e\left(e^{2x}\right)^2 - 3e^{2x} - 10e^{-1}$ $[=0]$ oe or $e^2\left(e^{2x}\right)^2 - 3e\left(e^{2x}\right) - 10$ $[=0]$oe or $e^2\left(e^{x}\right)^4 - 3e\left(e^{x}\right)^2 - 10$ $[=0]$ oe	**(B1)**	
	Solves or factorises *their* 3-term quadratic in e^{2x} oe	**(M1)**	**FT** *their* 3-term quadratic in e^{2x}
	$e^{2x} = \dfrac{5}{e}$ or 1.839[…] or $e^x = \sqrt{\dfrac{5}{e}}$ or 1.356[…] nfww	**(A1)**	
	$x = \dfrac{1}{2}\ln\dfrac{5}{e}$ oe, isw or 0.305 or 0.3047[18…] isw	**(A1)**	and no other solution
6	$\dfrac{5-\sqrt{3}}{\left(\sqrt{6}+\sqrt{2}\right)^2}$ soi	**B1**	
	$\left(\sqrt{6}+\sqrt{2}\right)^2 = 6 + 2 + 2\sqrt{12}$ or $8 + 2\sqrt{12}$	**B1**	
	$\dfrac{5-\sqrt{3}}{8+4\sqrt{3}} \times \dfrac{8-4\sqrt{3}}{8-4\sqrt{3}}$ or $\dfrac{5-\sqrt{3}}{4\left(2+\sqrt{3}\right)} \times \dfrac{2-\sqrt{3}}{2-\sqrt{3}}$ oe	**M1**	**FT** $\dfrac{a\left(5-\sqrt{3}\right)}{b+c\sqrt{d}}$ where *a*, *b*, and *c* are non-zero constants and *d* is an integer
	$\dfrac{40-20\sqrt{3}-8\sqrt{3}+12}{8^2-(4\sqrt{3})^2}$ or $\dfrac{40-20\sqrt{3}-8\sqrt{3}+12}{64-48}$ or $\dfrac{10-5\sqrt{3}-2\sqrt{3}+3}{4(2^2-(\sqrt{3})^2)}$ or $\dfrac{10-5\sqrt{3}-2\sqrt{3}+3}{4}$	**A1**	
	$\dfrac{13}{4} - \dfrac{7}{4}\sqrt{3}$ oe, nfww	**A1**	**dep** on all previous marks awarded

Question	Answer	Marks	Partial marks
7(a)(i)	252	**B1**	
7(a)(ii)	56	**B2**	**B1** for ${}^{8}C_{3}$ or $\frac{8!}{5!\times 3!}$ oe
7(a)(iii)	140	**B2**	**B1** for ${}^{8}C_{4} \times 2$ oe or ${}^{10}C_{5} - {}^{8}C_{5} - {}^{8}C_{3}$ oe
7(b)	483 840	**B3**	**B2** for 8! × 6 [× 2] or 241 920 oe or **B1** for 8! or 40 320 or 8! × 2 or 80 640
8	$\mathrm{cosec}^2 2\theta + 3\mathrm{cosec}\, 2\theta - 10$ [= 0] or $10\sin^2 2\theta - 3\sin 2\theta - 1$ [= 0]	**B2**	**B1** for correctly writing the equation in terms of one trigonometric function e.g. $\mathrm{cosec}^2 2\theta - 1 + 3\,\mathrm{cosec}\, 2\theta = 9$ or $\frac{1-\sin^2 2\theta}{\sin^2 2\theta} + \frac{3}{\sin 2\theta} = 9$
	Solves or factorises *their* 3-term quadratic in $\mathrm{cosec}2\theta$ or $\sin 2\theta$ e.g. $(\mathrm{cosec}\, 2\theta - 2)(\mathrm{cosec}\, 2\theta + 5)$ [= 0] or $(2\sin 2\theta - 1)(5\sin 2\theta + 1)$ [= 0]	**M1**	**FT** *their* 3-term quadratic in $\mathrm{cosec}2\theta$ or $\sin 2\theta$
	[$\sin 2\theta = \frac{1}{2}$ $\sin 2\theta = -\frac{1}{5}$ θ =] 15 75 −5.8 or –5.76 to –5.77 −84.2 or –84.23 to –84.232 and no other angles in range; nfww	**A3**	**A2** for any 2 correct, ignoring extras in range; nfww or **A1** for one correct angle or one correct double angle; nfww

Question	Answer	Marks	Partial marks
9(a)	Horizontal line, $v = 6$ for $0 \leqslant t \leqslant 5$	**B1**	
	Horizontal line, $v = -3$ for $5 \leqslant t \leqslant 15$	**B2**	**B1** for horizontal line for $5 \leqslant t \leqslant 15$ with $v = k$ where $k < 0$ or $v = 3$ for $5 \leqslant t \leqslant 15$ or $v = -3$ for $t > 5$ and at least $7 \leqslant t \leqslant 13$ If **0** scored, award: **SC2** for Horizontal line, $v = –6$ for $0 \leqslant t \leqslant 5$ **and** Horizontal line, $v = 3$ for $5 \leqslant t \leqslant 15$ **OR SC1** for Horizontal line, $v = –6$ for $0 \leqslant t \leqslant 5$ **and** Horizontal line for $5 \leqslant t \leqslant 15$ with $v = k$ where $k > 0$
9(b)	Single line with positive gradient passing through (0, –8), (10, 0) and (20, 8)	**B3**	**B2** for a single line with positive gradient • passing through a point indicated as (0, –8) or (20, 8) **and** the point (10, 0) • or passing through points indicated as (0, –8) and (20, 8) which does not pass through (10, 0) or **B1** for a single line with positive gradient • passing through a point indicated as (0, –8) or (20, 8) to or through any point on the *t*-axis • or passing through (10, 0) but with both endpoints incorrect or unlabelled If 0 scored, award **SC1** for a single line with negative gradient passing through (0, 8), (10, 0) and (20, –8)

Question	Answer	Marks	Partial marks
10(a)	Maximum point at (2, 1) oe, nfww and h = 5 nfww	**B4**	**B3** for maximum point at (2, 1) oe or **B2** for maximum point when x = 2 or **B1** for a correct method which could be used to find the maximum point $\left[x\left(1-\frac{x}{4}\right)=0 \text{ when } x=0 \text{ and}\right]$ x = 4 or [differentiating and equating to 0:] $1-\frac{2x}{4}=0$ or [completing the square to find:] $1-\frac{1}{4}(x-2)^2$ If 0 scored, **SC1** for h = 5 with incorrect or no method shown
10(b)	$x^2-4x-16$ [= 0] oe or $-\frac{1}{4}(x-2)^2=-4-1$ oe	**B1**	**FT** *their* attempt to complete the square, if already seen and of the form $a+b(x+c)^2$ where a, b and c are constants and b is negative
	Solves *their* 3-term quadratic using the formula or completing the square	**M1**	**FT** *their* rearrangement of $-4=x-\frac{x^2}{4}$ oe
	$x=2+2\sqrt{5}$ oe	**A1**	
10(c)	First derivative $1-\frac{x}{2}$ and substitution of *their* $2+2\sqrt{5}$ or 6.47	**M1**	**FT** *their* attempt to differentiate $x-\frac{x^2}{4}$, if already seen, and *their* $2+2\sqrt{5}$
	$1-2\times\frac{2+2\sqrt{5}}{4}$ or $-\sqrt{5}$ or awrt –2.24 soi	**A1**	**dep** on correct derivative and correct x-coordinate of A
	Correct method to find the angle e.g. $-\tan^{-1}\left(1-2\times\frac{2+2\sqrt{5}}{4}\right)$ soi or $\tan^{-1}\sqrt{5}$ or $-\tan^{-1}(-\sqrt{5})$ soi	**M1**	**dep** on previous **M1 A1**
	Degrees: awrt 65.9 or Radians: awrt 1.15	**A1**	
11(a)	x = 5 y = $5\sqrt{3}$	**B2**	**B1** for either component correct

Question	Answer	Marks	Partial marks
11(b)	$\left[\begin{pmatrix}0\\0\end{pmatrix}+\right]\quad t\begin{pmatrix}5\\5\sqrt{3}\end{pmatrix}$ oe, isw	**B1**	**FT** *their* $\begin{pmatrix}5\\5\sqrt{3}\end{pmatrix}$, which must be a vector with at least one non-zero component
11(c)	$\begin{pmatrix}2\sqrt{3}\\9\end{pmatrix}+t\begin{pmatrix}\frac{5}{3}\\0\end{pmatrix}$ oe, isw	**B2**	**B1** for x component $2\sqrt{3}+\frac{5}{3}t$ seen or y component 9 seen or $\begin{pmatrix}2\sqrt{3}\\9\end{pmatrix}+t\begin{pmatrix}\frac{5}{3}\\0\end{pmatrix}$ with at most one error but must include t
11(d)	$5t\sqrt{3}=9$ or $5t=2\sqrt{3}+\frac{5}{3}t$	**M1**	**FT** *their* position vector of A and *their* position vector of B providing • both are in terms of t and • at least one is of form $\begin{pmatrix}a\\b\end{pmatrix}+t\begin{pmatrix}c\\d\end{pmatrix}$ where a, b, c and d are constants
	$\left(5\sqrt{3}\right)t=9$ and $5t=2\sqrt{3}+\frac{5}{3}t$ oe	**A1**	
	Shows the exact times to be the same e.g. $t=\frac{9}{5\sqrt{3}}=\frac{3\sqrt{3}}{5}$ oe **<u>and</u>** $\frac{10}{3}t=2\sqrt{3}\to t=\frac{3\sqrt{3}}{5}$ or $t=\frac{6\sqrt{3}}{10}\to t=\frac{3\sqrt{3}}{5}$ or $\frac{5}{3}t=\sqrt{3}\to t=\frac{3\sqrt{3}}{5}$ oe OR Finds a correct value for t, as above, and shows this satisfies the other equation OR Finds a correct value for t, as above, and shows both particles are at $\begin{pmatrix}\frac{9}{\sqrt{3}}\\9\end{pmatrix}$ oe at this time	**A2**	**A1** for $t=\frac{9}{5\sqrt{3}}$ **and** $t=\frac{2\sqrt{3}}{\frac{10}{3}}$ oe

Question	Answer	Marks	Partial marks
12	Correct use of $x^2h = 5$ to find an expression that can be used to eliminate h	M2	**M1** for $x^2h = 5$ soi
	Surface area: $x^2 + 4x\left(\frac{5}{x^2}\right)$ oe	B1	
	Derivative of the surface area: $2x - 20x^{-2}$ oe	B1	**FT** *their* surface area of form $ax^2 + \frac{b}{x}$
	Equates *their* $2x - 20x^{-2}$ to 0 and solves to find a value of x	M1	**FT** *their* derivative of form $ax + \frac{b}{x^2}$ oe
	$x = 2.15$ or 2.154[…] $h = 1.08$ or 1.077[…] nfww	A1	**dep** on all previous marks awarded
	Alternative		
	Correct use of $x^2h = 5$ to find an expression that can be used to eliminate x	(M2)	**M1** for $x^2h = 5$ soi
	Surface area: $\left(\sqrt{\frac{5}{h}}\right)^2 + 4h\times\sqrt{\frac{5}{h}}$ oe	(B1)	
	Derivative of the surface area: $4\sqrt{5}\times\frac{1}{2}h^{-\frac{1}{2}} - \frac{5}{h^2}$ oe	(B1)	**FT** *their* surface area of form $\frac{a}{h} + b\sqrt{h}$
	Equates *their* $4\sqrt{5}\times\frac{1}{2}h^{-\frac{1}{2}} - \frac{5}{h^2}$ to 0 and solves to find a value of h	(M1)	**FT** *their* derivative of form $\frac{a}{\sqrt{h}} + \frac{b}{h^2}$ oe
	$h = 1.08$ or 1.077[…] $x = 2.15$ or 2.154[…] nfww	(A1)	**dep** on all previous marks awarded

