Question	Answer	Marks	Guidance
1	$\frac{6x}{2}$, $15 \times \frac{x^2}{4}$	B1 B1	OE In or from a correct expansion. Can be implied by correct equation.
	$\times (4 + ax) \to 3a + 15 = 3$	M1	2 terms in x^2 equated to 3 or $3x^2$. Condone x^2 on one side only.
	$a = -4$	A1	CAO
		4	

Question	Answer	Marks	Guidance
2	Attempt to find the midpoint *M*	M1	
	(1, 4)	A1	
	Use a gradient of $\pm\frac{2}{3}$ and *their M* to find the equation of the line.	M1	
	Equation is $y - 4 = -\frac{2}{3}(x - 1)$	A1	AEF
	Alternative method for question 2		
	Attempt to find the midpoint *M*	M1	
	(1, 4)	A1	
	Replace 1 in the given equation by c and substitute *their M*	M1	
	Equation is $y - 4 = -\frac{2}{3}(x - 1)$	A1	AEF
		4	

Question	Answer	Marks	Guidance
3	$(y=)\ \dfrac{kx^{-\frac{1}{2}+1}}{-\frac{1}{2}+1}\left(=\dfrac{k\sqrt{x}}{\frac{1}{2}}\right)\ (+c)$	**B1**	OE
	Substitutes both points into an integrated expression with a '+c' and solve as far as a value for one variable.	**M1**	Expect to see $-1 = 2k + c$ and $4 = 4k + c$
	$k = 2½$ **and** $c = -6$	**A1**	WWW
	$y = 5\sqrt{x} - 6$	**A1**	OE From correct values of both k & c and correct integral.
		4	

Question	Answer	Marks	Guidance
4(i)	Arc length $AB = 2r\theta$	**B1**	
	$\text{Tan}\ \theta = \dfrac{AT}{r}$ or $\dfrac{BT}{r} \rightarrow AT\ or\ BT = r\tan\theta$	**B1**	Accept or $\sqrt{\left(\left(\dfrac{r}{\cos\theta}\right)^2 - r^2\right)}$ or $\dfrac{r\sin\theta}{\sin\left(\dfrac{\pi}{2}-\theta\right)}$ NOT $(90-\theta)$
	$P = 2r\theta + 2r\tan\theta$	**B1FT**	OE, FT for *their* arc length + 2 × *their* AT
		3	

Question	Answer	Marks	Guidance
4(ii)	Area $\Delta AOT = ½ \times 5 \times 5 \tan 1.2$ **or** Area $AOBT = 2 \times ½ \times 5 \times 5 \tan 1.2$	**B1**	
	Sector area = $½ \times 25 \times 2.4$ (or 1.2)	***M1**	Use of $½r^2\theta$ with $\theta = 1.2$ or 2.4.
	Shaded area = 2 triangles – sector	**DM1**	Subtraction of sector, using 2.4 where appropriate, from 2 triangles
	Area = 34.3 (cm^2)	**A1**	AWRT
	Alternative method for question 4(ii)		
	Area of $\Delta\, ABT = ½ \times (5 \times \tan 1.2)^2 \times \sin(\pi - 2.4)$ (= 55.86)	**B1**	
	Segment area = $½ \times 25 \times (2.4 - \sin 2.4)$ (= 21.56)	***M1**	Use of $½r^2 (\theta - \sin\theta)$ with $\theta = 1.2$ or 2.4
	Shaded area = triangle – segment	**DM1**	Subtraction of segment from $\Delta\, ABT$, using 2.4 where appropriate.
	Area = 34.3 (cm^2)	**A1**	AWRT
		4	

Question	Answer	Marks	Guidance
5(i)	Use of Pythagoras $\rightarrow r^2 = 15^2 - h^2$	**M1**	
	$V = ⅓\pi(225 - h^2) \times h \rightarrow ⅓\pi(225h - h^3)$	**A1**	AG WWW e.g. sight of $r = 15 - h$ gets A0.
		2	

Question	Answer	Marks	Guidance
5(ii)	$\left(\frac{dv}{dh}=\right)\frac{\pi}{3}(225-3h^2)$	B1	
	Their $\frac{dv}{dh}=0$	M1	Differentiates, sets *their* differential to 0 and attempts to solve at least as far as $h^2 \neq 0$.
	$(h =)$ $\sqrt{75}$, $5\sqrt{3}$ or AWRT 8.66	A1	Ignore $-\sqrt{75}$ OE and ISW for both A marks
	$\frac{d^2h}{dh^2}=\frac{\pi}{3}$ $(-6h)$ $(\rightarrow -\text{ve})$	M1	Differentiates for a second time and considers the sign of the second differential or any other valid complete method.
	$\rightarrow$ Maximum	A1FT	Correct conclusion from correct 2nd differential, value for h not required, or any other valid complete method. FT for *their* h, if used, as long as it is positive.
			SC Omission of π or $\frac{\pi}{3}$ throughout can score B0M1A1M1A0
		5	

Question	Answer	Marks	Guidance
6(a)	$(2x + 1) = \tan^{-1}(⅓)$ (= 0.322 or 18.4 OR −0.339 rad or 8.7°)	*M1	Correct order of operations. Allow degrees.
	Either *their* 0.322 + π or 2π Or *their* −0.339 + $\frac{\pi}{2}$ or π	DM1	Must be in radians
	$x = 1.23$ **or** $x = 2.80$	A1	AWRT for either correct answer, accept 0.39π or 0.89π
		A1	For the second answer with no other answers between 0 and 2.8 **SC1** For both 1.2 and 2.8
		4	
6(b)(i)	$5\cos^2 x - 2$	B1	Allow $a = 5$, $b = -2$
		1	
6(b)(ii)	−2	B1FT	FT for sight of *their* b
	3	B1FT	FT for sight of *their* $a + b$
		2	

Question	Answer	Marks	Guidance
7(i)	$\left(\overrightarrow{PB}\right) = 5\mathbf{i} + 8\mathbf{j} - 5\mathbf{k}$	B2,1,0	B2 all correct, B1 for two correct components.
	$\left(\overrightarrow{PQ}\right) = 4\mathbf{i} + 8\mathbf{j} + 5\mathbf{k}$	B2,1,0	B2 all correct, B1 for two correct components.
			Accept column vectors. **SC** B1 for each vector if all components multiplied by –1.
		4	
7(ii)	(Length of *PB* =) $\sqrt{\left(5^2 + 8^2 + 5^2\right)} = (\sqrt{114} \approx 10.7)$ (Length of *PQ* =) $\sqrt{\left(4^2 + 8^2 + 5^2\right)} = (\sqrt{105} \approx 10.2)$	M1	Evaluation of both lengths. Other valid complete comparisons can be accepted.
	P is nearer to *Q*.	A1	WWW
		2	
7(iii)	$\left(\overrightarrow{PB}.\overrightarrow{PQ}\right) = 20 + 64 - 25$	M1	Use of $x_1x_2 + y_1y_2 + z_1z_2$ on *their* $\overrightarrow{PB}$ and $\overrightarrow{PQ}$
	$(Their\sqrt{114})(their\sqrt{105})\cos BPQ = (their\ 59)$	M1	All elements present and in correct places.
	$BPQ = 57.4(°)$ or 1.00 (rad)	A1	AWRT Calculating the obtuse angle and then subtracting gets A0.
		3	

Question	Answer	Marks	Guidance
8(a)(i)	21st term = 13 + 20 × 1.2 = 37 (km)	B1	
		1	

Question	Answer	Marks	Guidance
8(a)(ii)	$S_{21} = \frac{1}{2} \times 21 \times (26 + 20 \times 1.2)$ or $\frac{1}{2} \times 21 \times (13 + \textit{their } 37)$	**M1**	A correct sum formula used with correct values for a, d and n.
	525 (km)	**A1**	
		2	
8(b)(i)	$\frac{x-3}{x} = \frac{x-5}{x-3}$ oe (or use of a, ar and ar^2)	**M1**	Any valid method to obtain an equation in one variable.
	(a = *or* x =) 9	**A1**	
		2	
8(b)(ii)	$r = \left(\frac{x-3}{x}\right)$ or $\left(\frac{x-5}{x-3}\right)$ or $\sqrt{\frac{x-5}{x}} = \frac{2}{3}$. Fourth term $= 9 \times \left(\frac{2}{3}\right)^3$	**M1**	Any valid method to find r and the fourth term with *their* a & r.
	$2\frac{2}{3}$ **or** 2.67	**A1**	OE, AWRT
		2	
8(b)(iii)	$S_\infty = \frac{a}{1-r} = \frac{9}{1-\frac{2}{3}}$	**M1**	Correct formula and using *their* 'r' and 'a', with $\lvert r \rvert < 1$, to obtain a numerical answer.
	27 **or** 27.0	**A1**	AWRT
		2	

Question	Answer	Marks	Guidance
9(i)	$f(x) = g(x) \rightarrow 2x^2 + 6x + 1 + k\ (= 0)$	*M1	Forms a quadratic with all terms on same side.
	Use of $b^2 = 4ac$	DM1	Uses the discriminant = 0.
	$(k =)\ 3\frac{1}{2}$	A1	OE, WWW
	Alternative method for question 9(i)		
	$4x + 8 = 2\ (\rightarrow x = -1\frac{1}{2})$	*M1	Differentiating, equating gradients and solving to give $x =$
	Substitutes *their* x value into either $2x^2 + 6x + 1 + k = 0$ OR into the curve to find $y\left(= \frac{-13}{2}\right)$ then both values into the line.	DM1	Substituting appropriately for *their* x and proceeding to find a value of k.
	$(k =)\ 3\frac{1}{2}$	A1	OE, WWW
		3	
9(ii)	$2x^2 + 6x - 8\ (< 0)$	M1	Forms a quadratic with all terms on same side
	-4 and 1	A1	
	$-4 < x < 1$	A1	CAO
		3	
9(iii)	$(g^{-1}(x)) = \frac{x-1}{2}$	B1	Needs to be in terms of x.
	$(g^{-1}f(x)) = \frac{2x^2 + 8x + 1 - 1}{2} = 0 \rightarrow (2x^2 + 8x = 0) \rightarrow x =$	M1	Substitutes f into g^{-1} and attempts to solve it = 0 as far as $x =$
	$0, -4$	A1	CAO
		3	

Question	Answer	Marks	Guidance
9(iv)	$2(x+2)^2-7$	B1 B1	or $a=+2$, $b=-7$
	(Least value of f(x) or y =) -7 or $\geqslant -7$	B1FT	FT for *their* b from a correct form of the expression.
		3	

Question	Answer	Marks	Guidance
10(i)	$\frac{dy}{dx}=[0]+\left[(2x+1)^{-3}\right]\times[+16]$	B2,1,0	OE. Full marks for 3 correct components. Withhold one mark for each error or omission.
	$\int y dx=[x]+\left[(2x+1)^{-1}\right]\times[+2]$ (+c)	B2,1,0	OE. Full marks for 3 correct components. Withhold one mark for each error or omission.
		4	
10(ii)	At A, $x=½$.	B1	Ignore extra answer $x=-1.5$
	$\frac{dy}{dx}=2\rightarrow$ Gradient of normal $(=-½)$	*M1	With *their* positive value of x at A and *their* $\frac{dy}{dx}$, uses $m_1m_2=-1$
	Equation of normal: $y-0=-½(x-½)$ or $y-0=-½(0-½)$ or $0=-½\times½+c$	DM1	Use of *their* x at A and *their* normal gradient.
	B (0, ¼)	A1	
		4	

Question	Answer	Marks	Guidance
10(iii)	$\int_0^{\frac{1}{2}} 1 - \frac{4}{(2x+1)^2} (\mathrm{d}x)$	*M1	$\int y\,\mathrm{d}x$ SOI with 0 and *their* positive x coordinate of A.
	[½ + 1] – [0 + 2] = (–½)	DM1	Substitutes both 0 and *their* ½ into *their* $\int y\mathrm{d}x$ and subtracts.
	Area of triangle above x-axis = ½ × ½ × ¼ $\left(= \frac{1}{16}\right)$	B1	
	Total area of shaded region = $\frac{9}{16}$	A1	OE (including AWRT 0.563)
	Alternative method for question 10(iii)		
	$\int_{-3}^{0} \frac{1}{(1-y)^{\frac{1}{2}}} - \frac{1}{2} (\mathrm{d}y)$	*M1	$\int x\,\mathrm{d}y$ SOI. Where x is of the form $k\left((1-y)^{-\frac{1}{2}} + c\right)$ with 0 and *their* negative y intercept of curve.
	$[-2] - \left[-4 + \frac{3}{2}\right] = (½)$	DM1	Substitutes both 0 and *their* –3 into *their* $\int x\mathrm{d}y$ and subtracts.
	Area of triangle above x-axis = ½ × ½ × ¼ $\left(= \frac{1}{16}\right)$	B1	
	Total area of shaded region = $\frac{9}{16}$	A1	OE (including AWRT 0.563)

Question	Answer	Marks	Guidance
	Alternative method for question 10(iii)		
	$\int_0^{\frac{1}{2}} -\frac{1}{2}x + \frac{1}{4} - y \, dx$	*M1	∫(*their* normal curve) with 0 and *their* positive x coordinate of A.
	Curve [½ + 1] – [0 + 2] = (−½)	DM1	Substitutes both 0 and *their* ½ into *their* ∫ydx and subtracts.
	$\int_0^{\frac{1}{2}} -\frac{1}{2}x + \frac{1}{4} dx = \frac{-x^2}{4} + \frac{x}{4} = \left[\frac{-1}{16} + \frac{1}{8}\right] - [0] \left(= \frac{1}{16}\right)$	B1	Substitutes both 0 and ½ into the correct integral and subtracts.
	Total area of shaded region = $\frac{9}{16}$	A1	OE (including AWRT 0.563)
		4	