Question	Answer	Marks	Guidance
1	$p^{-\frac{3}{2}}q^{\frac{8}{3}}r^{-2}$	3	**B1** for $a=-\frac{3}{2}$ **B1** for $b=\frac{8}{3}$ **B1** for $c=-2$
2(a)	$\frac{\mathrm{d}s}{\mathrm{d}t}=-\frac{3}{2}(1+3t)^{-\frac{3}{2}}$	2	**M1** for $a(1+3t)^{-\frac{3}{2}}$ **A1** all correct
	When t = 1, $\frac{\mathrm{d}s}{\mathrm{d}t}=-\frac{3}{16}$ Speed = $\frac{3}{16}$	A1	
2(b)	Acceleration = $\frac{27}{4}(1+3t)^{-\frac{5}{2}}$	B1	Allow unsimplified
	$(1+3t)^{-\frac{5}{2}}$ is always positive (so acceleration can never be zero.)	B1	Any valid explanation.
3(a)	$\mathrm{f}(x) \in \mathbb{R}$ oe	B1	Must be using correct notation, allow $y \in$
3(b)	$5(\ln(3x+1))-7=13$	M1	For correct order
	$x=\frac{\mathrm{e}^4-1}{2}$	2	**M1** for a correct attempt to solve to get $x =$, allow one sign error **Dep** on previous M mark **A1** all correct must be exact
3(c)	$(\mathrm{f}'(x)=)\ \frac{2}{2x+1}$	2	**M1** for $\frac{a}{2x+1}$ **A1** all correct
	$(\mathrm{g}^{-1}(x)=)\ \frac{x+7}{5}$	B1	soi
	$2x^2+15x-3=0$	M1	for equating and forming a 3-term quadratic equation = 0
	$x = 0.195, -7.69$	M1	For solution of *their* 3-term quadratic
	$x = 0.195$	A1	For discounting negative root.
4(a)	$[\mathrm{f}(x)=]\pm 4(x+2)(x-1)(x-3)$	3	**B1** for $\pm$ **B1** for 4 **B1** for $(x+2)(x-1)(x-3)$

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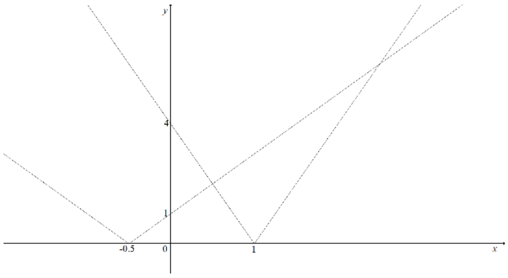
4(b)(i)		**3**	**B1** for 2 V shapes which intersect twice in the first quadrant, with vertices on the x-axis, must be straight lines, not curves. **B1** for –0.5 and 1 on the x-axis **B1** for 1 and 4 on the y-axis
4(b)(ii)	$2x + 1 = 4(x - 1)$	**M1**	For attempt to solve to get $x =$
	$x = 2.5$	**A1**	
	$2x + 1 = -4(x - 1)$ oe	**M1**	For attempt to solve to get $x =$
	$x = 0.5$	**A1**	
	Alternative $4x^2 + 4x + 1 = 16x^2 - 32x + 16$	**(M1)**	 For attempt to square each equation and equate
	$12x^2 - 36x + 15 = 0$ oe	**(M1)**	Dep on previous M mark for attempt to simplify to a 3-term quadratic equation, equated to zero and attempt to solve
	$x = 2.5$ $x = 0.5$	**(A2)**	**A1** for each
5(a)	$\begin{pmatrix} -7.5 \\ 4 \end{pmatrix}$ or $-\frac{1}{2}\begin{pmatrix} 15 \\ -8 \end{pmatrix}$ oe	**2**	**B1** for $\begin{pmatrix} 7.5 \\ -4 \end{pmatrix}$ oe or **B1** for $\begin{pmatrix} -15 \\ 8 \end{pmatrix}$
5(b)	$15a + 2a + 1 = 6b + 6a$ $5b + 2 = 2$	**M1**	For equating like vectors in order to obtain at least one equation
	$a = 1$, $b = 2$	**2**	**Dep M1** for attempt to solve both equations **A1** for both
6(a)	$k = 14$	**B1**	
	$k = 6$	**B1**	

Question	Answer	Marks	Guidance
6(b)(i)	$\dfrac{(1+\tan\theta)(1+\cos\theta)+(1-\tan\theta)(1-\cos\theta)}{1-\cos^2\theta}$	**M1**	Allow $(1 + \cos\theta)(1 - \cos\theta)$ in the denominator
	Expansion of numerator and simplification of denominator	**M1**	**Dep** on previous M mark
	Use of $\tan\theta\cos\theta = \sin\theta$	**B1**	soi
	$\dfrac{2(1+\sin\theta)}{\sin^2\theta}$	**A1**	Sufficient simplification to justify obtaining the given answer
6(b)(ii)	$2(1 + \sin\theta) = 3\sin^2\theta$ $3\sin^2\theta - 2\sin\theta - 2 = 0$	**M1**	For use of part **(a)** and attempt to simplify to a 3-term quadratic equation equated to zero.
	$\sin\theta = \dfrac{1-\sqrt{7}}{3}$ or –0.5485…	**M1**	**M1** for attempt to solve and obtain a value for θ, may be implied by one correct solution
	213.3° and 326.7°	**A2**	**A1** for one solution If 0 scored **SC1** for awrt 213 and 327 Penalise excess solutions in the range
7(a)	Common difference = 2 lg 3	**B1**	Must be exact
	$\dfrac{n}{2}(2\lg 3 + (n-1)2\lg 3) = 256\lg 81$ or $\dfrac{n}{2}(\lg 9 + (n-1)\lg 9) = 512\lg 9$	**M1**	For use of the sum formula
	$\lg 81 = 4\lg 3$ soi or $\lg 81 = 2\lg 9$ soi	**B1**	Allow when working with decimal
	$n^2 = 1024$ oe	**M1**	Dep on first M mark, for attempt to simplify the sum equation by dividing through by lg3 oe to obtain an equation in *n* only
	$n = 32$ cao	**A1**	Must have exact working through out
7(b)	$\ln 256 = 4\ln 4$, $\ln 16 = 2\ln 4$ oe	**M1**	For use of power rule to obtain the common ratio
	Common ratio = 0.5	**A1**	
	$S_\infty = \dfrac{4\ln 4}{1-\textit{their } r}$ oe	**M1**	Allow ln256 for first term and *their r* provided it is positive and < 1
	$16\ln 2$	**A1**	

Question	Answer	Marks	Guidance
8(a)	$x^2 + 2\sqrt{5}x - 20 = 3\sqrt{5}x + 10$ $x^2 - \sqrt{5}x - 30 = 0$	M1	For equating *x* terms and simplifying to a 3-term quadratic equation equated to zero.
	$x = \dfrac{\sqrt{5} \pm \sqrt{5-(4\times -30)}}{2}$ oe	M1	**Dep** on previous M mark for attempt to solve to obtain *x* =, sufficient detail must be shown
	$x = 3\sqrt{5}$ $x = -2\sqrt{5}$	A1	For both
	$y = 55$, $y = -20$	A1	For both
8(b)	Use of $\operatorname{cosec}^2\theta = 1 + \cot^2\theta$	B1	May be implied by later work
	$\operatorname{cosec}^2\theta = 1 + \dfrac{(2+\sqrt{3})^2}{(\sqrt{3}-1)^2}$	M1	For attempting to deal with tan correctly, forming a single fraction and simplifying, with sufficient detail – at least 4 terms in the numerator
	$\operatorname{cosec}^2\theta = \dfrac{11+2\sqrt{3}}{4-2\sqrt{3}}$	A1	
	$\operatorname{cosec}^2\theta = \dfrac{11+2\sqrt{3}}{4-2\sqrt{3}} \times \dfrac{4+2\sqrt{3}}{4+2\sqrt{3}}$	M1	For attempt to rationalise *their* expression, with sufficient detail in the simplification of the numerator – at least 3 terms
	$14 + \dfrac{15\sqrt{3}}{2}$	A1	
	Alternative 1 Use of $\operatorname{cosec}^2\theta = 1 + \cot^2\theta$	(B1)	 May be implied by later work
	$\cot\theta = \dfrac{2+\sqrt{3}}{\sqrt{3}-1}$ $= \dfrac{3\sqrt{3}+5}{2}$	(2)	**M1** for attempting to rationalise $\cot\theta$ or tan with sufficient detail in the simplification of the numerator – at least 3 terms
	$\operatorname{cosec}^2\theta = 1 + \left(\dfrac{3\sqrt{3}+5}{2}\right)^2$ $= 14 + \dfrac{15\sqrt{3}}{2}$	(2)	**M1** for expressing as a single fraction and attempt to simplify to required form.

Question	Answer	Marks	Guidance
8(b)	**Alternative 2** Use of $\text{cosec}^2\,\theta = 1 + \cot^2\,\theta$ **and** $\cot^2\theta = \dfrac{1}{\tan^2\theta}$	**(B1)**	May be implied by later work
	$\tan^2\theta = \dfrac{4-\sqrt{3}}{7+4\sqrt{3}}$ $= 52 - 30\sqrt{3}$	**(2)**	**M1** for attempting to rationalise $\tan^2\,\theta$ with sufficient detail in the simplification of the numerator – at least 3 terms
	$\text{cosec}^2\theta = 1 + \left(\dfrac{1}{52-30\sqrt{3}}\right)^2$ $= 14 + \dfrac{15\sqrt{3}}{2}$	**(2)**	**M1** for attempting to rationalise $\cot^2\,\theta$ with sufficient detail in the simplification of the numerator – at least 3 terms **and** expressing as a single fraction and attempt to simplify to required form.
	Alternative 3 Use of right-angled triangle $\text{Hyp}^2 = 11 + 2\sqrt{3}$	**(2)**	**M1** For attempt to calculate the square of hypotenuse
	$\text{cosec}^2\theta = \dfrac{11+2\sqrt{3}}{4-2\sqrt{3}}$	**(B1)**	for correct use of $\text{cosec}^2\,\theta$ with *their* squared hypotenuse
	$\text{cosec}^2\theta = \dfrac{11+2\sqrt{3}}{4-2\sqrt{3}} \times \dfrac{4+2\sqrt{3}}{4+2\sqrt{3}}$	**(M1)**	For attempt to rationalise *their* expression, with sufficient detail in the simplification of the numerator – at least 3 terms
	$14 + \dfrac{15\sqrt{3}}{2}$	**A1**	
9(a)	$\dfrac{1}{2}r^2\theta = 10,\ \theta = \dfrac{20}{r^2}$	**B1**	
	$[P =]\ 2r + r\theta$	**M1**	For substituting *their* θ in P
	$[P =]\ 2r + \dfrac{20}{r}$	**A1**	
9(b)	$\dfrac{dP}{dr} = 2 - \dfrac{20}{r^2}$	**M1**	For attempt to differentiate *their* answer to part **(a)** to obtain the form of $\left[\dfrac{dP}{dr} =\right] 2 + \dfrac{a}{r^2}$
	When $\dfrac{dP}{dr} = 0,\ r = \sqrt{10}$	**2**	**Dep M1** for equating *their* $\dfrac{dP}{dr}$ to zero and attempt to solve **A1** cao

Question	Answer	Marks	Guidance
9(c)	$\frac{d^2P}{dr^2} = \frac{40}{r^3}$ As r is positive, $\frac{d^2P}{dr^2}$ is also positive so minimum	2	**M1** for a complete method, allow valid alternatives, if differentiated, must be in the form of $\left[\frac{d^2P}{dr^2} =\right]\frac{k}{r^3}$ **A1** for a correct conclusion
9(d)	$\theta = 2$	**B1**	
10	$-1 = \tan\left(3p + \frac{\pi}{2}\right)$ $p = \frac{\pi}{12}$	2	**M1** for a complete method to find the value of p
	$\frac{dy}{dx} = 3\sec^2\left(3x + \frac{\pi}{2}\right)$	2	**M1** for $a\sec^2\left(3x + \frac{\pi}{2}\right)$ **A1** all correct
	When $x = \frac{\pi}{12}$, $\frac{dy}{dx} = 6$	**M1**	For attempt to find the gradient using *their p* from differentiation
	Equation of normal: $y + 1 = -\frac{1}{6}\left(x - \frac{\pi}{12}\right)$	**M1**	For attempt at normal equation using *their p* and $-\frac{1}{\textit{their}\text{ value for }\frac{dy}{dx}}$
	When $x = 0$, $y = \frac{\pi}{72} - 1$	**M1**	For attempt to find B using *their* normal equation (must be from differentiation)
	When $y = 0$, $x = \frac{\pi}{12} - 6$	**M1**	For attempt to find A using *their* normal equation (must be from differentiation)
	Mid-point $\left(\frac{\pi}{24} - 3, \frac{\pi}{144} - \frac{1}{2}\right)$	2	**A1** for x value (must be exact) **A1** for y value (must be exact)