Question	Answer	Marks	Guidance
1(a)	3	**B2**	**B1** for g(0) = 0 or [fg(x) =] $2\sin(e^{3x} - 1) + 3\cos(e^{3x} - 1)$ soi
1(b)	$gg(x) = e^{3(e^{3x}-1)} - 1$ oe, isw	**B1**	
1(c)	$3y = \ln(x+1)$ or $3x = \ln(y+1)$ **and** swops the variables at some point	**M1**	condone one error
	$g^{-1}(x) = \frac{1}{3}\ln(x+1)$ soi	**A1**	
	[x =] 4	**A1**	
	Alternative method		
	$x = g(\frac{1}{3}\ln 5)$ soi	**(B1)**	
	$e^{3\left(\frac{1}{3}\ln 5\right)} - 1$ oe	**(M1)**	
	[x =] 4	**(A1)**	
2	Uses $b^2 - 4ac$ [*0] $k^2 - 4(4k - 15)$ [*0]	**M1**	where * is any inequality sign or =;
	$k^2 - 16k + 60$ [*0]	**A1**	
	$(k-6)(k-10)$ [*0]	**DM1**	**FT** *their* 3-term quadratic; **dep** on previous **M1**
	$6 < k < 10$	**A1**	Mark final answer
	Alternative method		
	$2x + k$ [= 0]	**(M1)**	
	$-\frac{k^2}{4} + 4k - 15$ [*0] oe or $-x^2 - 8x - 15$ [*0] oe	**(A1)**	
	Solves or factorises $(k-6)(k-10)$ [*0] or $(x + 5)(x + 3)$ [*0] **and** $x = -5$, $x = -3$	**(DM1)**	**FT** *their* 3-term quadratic; **dep** on previous **M1**
	$6 < k < 10$	**(A1)**	Mark final answer

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3(a)	Correctly eliminates $\log_2 x$ or $\log_2 y$	M1	A correct equation in $\log_2 x$ only or $\log_2 y$ only
	$x = 16$ or $y = 64$	A2	**A1** for $\log_2 x = 4$ or $\log_2 y = 6$
	$y = 64$ or $x = 16$	A2	**A1** for $\log_2 y = 6$ or $\log_2 x = 4$
	Alternative method		
	$x^3 y^2 = 2^{24}$ **and** $\frac{x^5}{y^3} = 2^2$ oe	(M1)	
	$y = 64$ or $x = 16$	(A2)	**A1** for $y^{19} = 2^{114}$ oe or $x^{19} = 2^{76}$ oe
	$x = 16$ or $y = 64$	(A2)	**A1** for $x^3 \times 64^2 = 2^{24}$ oe or $\frac{x^5}{64^3} = 2^2$ oe OR $16^3 \times y^2 = 2^{24}$ oe or $\frac{16^5}{y^3} = 2^2$ oe
3(b)	$2^{t+4-(1-2t)} = 2^9$ or $2^{t+4} = 2^{9+1-2t}$ oe, soi OR $t + 4 - (1-2t) = \log_2 512$ oe, soi or $t + 4 - (1-2t) = \frac{\log_a 512}{\log_a 2}$ oe	B2	**B1** for $2^{t+4-(1-2t)} = 512$ or $\frac{2^{t+4}}{2^{1-2t}} = 2^9$ soi OR $(t+4)\log_a 2 - (1-2t)\log_a 2 = \log_a 512$
	$3t + 3 = 9$ or better	M1	
	$t = 2$	A1	

Question	Answer	Marks	Guidance
4	$\dfrac{(x-1)^2}{x^3}=\dfrac{1}{x}-2x^{-2}+x^{-3}$ soi	**B2**	**B1** for $\dfrac{x^2-2x+1}{x^3}$ or $\dfrac{1}{x}-\dfrac{2}{x^2}+\dfrac{1}{x^3}$ or for any two terms correct in $\dfrac{1}{x}-2x^{-2}+x^{-3}$
	$\left[\ln x+\dfrac{2}{x}-\dfrac{1}{2x^2}\right]_3^5$	**B2**	**B1** for $\left[\ln x+...-\dfrac{1}{2x^2}\right]_3^5$ or $\left[\ln x+\dfrac{2}{x}+...\right]_3^5$ or $\left[k\ln x+\dfrac{2}{x}-\dfrac{1}{2x^2}\right]_3^5$ with $k\neq 0$
	$\left[\ln 5+\dfrac{2}{5}-\dfrac{1}{50}\right]-\left[\ln 3+\dfrac{2}{3}-\dfrac{1}{18}\right]$	**M1**	**dep** on at least previous **B1** for integration
	$\ln\left(\dfrac{5}{3}\right)-\dfrac{52}{225}$	**A1**	
5(a)	Correct use of $\pi r^2h=1000$ to find an expression that can be used to eliminate h e.g. $h=\dfrac{1000}{\pi r^2}$ or $\pi rh=\dfrac{1000}{r}$	**M2**	**M1** for $\pi r^2h=1000$ soi
	Correct substitution and completion to given answer e.g. $2\pi r^2+2\pi r\times\dfrac{1000}{\pi r^2}=2\pi r^2+\dfrac{2000}{r}$	**A1**	

Question	Answer	Marks	Guidance
5(b)	Correct derivative: $4\pi r - \dfrac{2000}{r^2}$ oe, isw	**B2**	**B1** for one correct term
	$4\pi r - \dfrac{2000}{r^2} = 0$ and solves for r	**M1**	**FT** *their* derivative providing that at least one term is correct
	$r = \sqrt[3]{\dfrac{2000}{4\pi}}$ oe, isw or 5.42 or 5.419[26…] rot to 3 or more dp	**A1**	
	Second derivative $\dfrac{d^2S}{dr^2} = 4\pi + 4000r^{-3}$ **and** When $r = 5.42$, $\dfrac{d^2S}{dr^2} > 0$ oe [hence minimum] or $4\pi + 4000(5.42)^{-3} > 0$ oe [hence minimum] or $\dfrac{d^2S}{dr^2} = 12\pi$ or 37 to 38 [hence minimum] or as $r > 0$, $\dfrac{d^2S}{dr^2} > 0$ [hence minimum] OR correctly finds the values of the first derivative at 5.42 oe $\pm h$, where h is small [hence minimum]	**A1**	**Dep** on previous mark
6(a)	Velocity: $\dfrac{8t}{4t^2-5} - 1$	**B2**	**B1** for $\dfrac{f(t)}{4t^2-5} - 1$ or for $\dfrac{8t}{4t^2-5} + g(t)$
	Correct structure of quotient rule or equivalent product rule	**M1**	**FT** *their* v if possible; must be of equivalent difficulty
	Acceleration: $\dfrac{(4t^2-5)(8)-(8t)(8t)}{(4t^2-5)^2}$ oe, isw	**A1**	**FT** $\dfrac{8t}{4t^2-5} + k$ where k is a constant
6(b)	$4t^2 - 8t - 5 = 0$ oe	**B1**	
	$(2t+1)(2t-5) = 0$	**M1**	**FT** *their* 3-term quadratic in t
	$t = 2.5$ and no other values	**A1**	**dep** on correct quadratic seen
6(c)	$\dfrac{(4\times 2.5^2-5)(8)-(8\times 2.5)(8\times 2.5)}{(4\times 2.5^2-5)^2}$ oe, soi	**M1**	Substitutes a value of $t > 2$ in an expression for a which has at least one term with a factor of $\dfrac{1}{\left(4t^2-5\right)^2}$ or $\dfrac{1}{16t^4-40t^2+25}$
	$a = -\dfrac{3}{5}$ oe only	**A1**	

Question	Answer	Marks	Guidance
7(a)	$\dfrac{BC}{\sin 60} = \dfrac{\sqrt{2}}{\sin 45}$ oe	**M1**	
	$BC = \sqrt{3}$ oe	**A1**	
	$\dfrac{1}{2} \times \sqrt{2} \times \sqrt{3} \times \sin 75 = \dfrac{3+\sqrt{3}}{4}$ OR height $= \left(\dfrac{3+\sqrt{3}}{4}\right) \times \dfrac{2}{\sqrt{3}}$ oe	**M1**	**FT** *their BC* providing it has not been found using the given result for sin75
	$\sin 75 = \dfrac{2(3+\sqrt{3})}{4\sqrt{6}}$ oe OR $\sin 75 = \dfrac{\left(\dfrac{3+\sqrt{3}}{4}\right) \times \dfrac{2}{\sqrt{3}}}{\sqrt{2}}$ oe $\left[= \dfrac{\dfrac{1+\sqrt{3}}{2}}{\sqrt{2}} = \dfrac{1+\sqrt{3}}{2\sqrt{2}} \right]$	**A1**	**dep** on all previous marks being awarded Isolates sin 75 correctly or deals with surds on LHS of correct equation e.g. $\dfrac{1}{2} \times 6 \times \sin 75 = \left(\dfrac{3+\sqrt{3}}{4}\right) \times \sqrt{6}$
	correct completion to given answer $\dfrac{\sqrt{6}+\sqrt{2}}{4}$	**A1**	must be convincing with an intermediate step if needed
	Alternative methods (finding *AC* first)		
	$\dfrac{1}{2} \times \sqrt{2} \times AC \times \sin 60 = \dfrac{3+\sqrt{3}}{4}$ oe	**(M1)**	
	$AC = \dfrac{2}{\sqrt{2}} \times \dfrac{2}{\sqrt{3}} \times \dfrac{3+\sqrt{3}}{4}$ oe	**(A1)**	Isolates *AC* correctly
	$AC = \dfrac{\sqrt{2}+\sqrt{6}}{2}$	**(A1)**	Must be convinced no calculator is being used
	$\dfrac{\sin 75}{\dfrac{\sqrt{2}+\sqrt{6}}{2}} = \dfrac{\sin 45}{\sqrt{2}}$ oe	**(M1)**	**FT** *their AC* May simplify to $\sin 75 = \dfrac{AC}{2}$ before inserting *their AC*
	correct completion to given answer $\dfrac{\sqrt{6}+\sqrt{2}}{4}$	**(A1)**	**dep** on all previous marks being awarded must be convincing with an intermediate step if needed

Question	Answer	Marks	Guidance
7(b)	$\dfrac{AC}{\frac{\sqrt{6}+\sqrt{2}}{4}} = \dfrac{\frac{\sqrt{2}}{2}}{\frac{\sqrt{2}}{2}}$ or $\dfrac{AC}{\frac{\sqrt{6}+\sqrt{2}}{4}} = \dfrac{\frac{\sqrt{3}}{2}}{\frac{\sqrt{3}}{2}}$ or better	**M1**	
	$\dfrac{\sqrt{6}+\sqrt{2}}{2}$ nfww	**A1**	
8(a)	$\dfrac{\sin x}{\frac{\sin x}{\cos x}-1} - \dfrac{\cos x}{\frac{\sin x}{\cos x}+1}$	**M1**	OR $\dfrac{\sin x(\tan x+1)-\cos x(\tan x-1)}{(\tan x-1)(\tan x+1)}$
	$\dfrac{\sin x}{\frac{\sin x-\cos x}{\cos x}} - \dfrac{\cos x}{\frac{\sin x+\cos x}{\cos x}}$ OR $\dfrac{\sin x\left(\frac{\sin x}{\cos x}+1\right)-\cos x\left(\frac{\sin x}{\cos x}-1\right)}{\frac{\sin^2 x}{\cos^2 x}-1}$	**A1**	OR $\dfrac{\sin x\tan x+\sin x-\cos x\tan x+\cos x}{(\tan x-1)(\tan x+1)}$ OR $\dfrac{\sin x\left(\frac{\sin x}{\cos x}+1\right)-\cos x\left(\frac{\sin x}{\cos x}-1\right)}{\left(\frac{\sin x}{\cos x}-1\right)\left(\frac{\sin x}{\cos x}+1\right)}$
	$\dfrac{\sin x\cos x}{\sin x-\cos x} - \dfrac{\cos^2 x}{\sin x+\cos x}$ OR $\dfrac{\sin x\left(\frac{\sin x+\cos x}{\cos x}\right)-\cos x\left(\frac{\sin x-\cos x}{\cos x}\right)}{\frac{\sin^2 x-\cos^2 x}{\cos^2 x}}$	**A1**	OR $\dfrac{\frac{\sin^2 x}{\cos x}+\sin x-\sin x+\cos x}{\frac{\sin^2 x}{\cos^2 x}-1}$
	$\dfrac{\sin^2 x\cos x+\sin x\cos^2 x-\cos^2 x\sin x+\cos^3 x}{\sin^2 x+\cos x\sin x-\cos x\sin x-\cos^2 x}$ OR $\dfrac{\sin^2 x+\sin x\cos x-\cos x\sin x+\cos^2 x}{\cos x}\times\dfrac{\cos^2 x}{\sin^2 x-\cos^2 x}$	**A1**	OR $\dfrac{\frac{\sin^2 x+\cos^2 x}{\cos x}}{\frac{\sin^2 x-\cos^2 x}{\cos^2 x}}$ or $\dfrac{\frac{\sin^2 x+\cos^2 x}{\cos x}}{\frac{1-2\cos^2 x}{\cos^2 x}}$
	Fully correct justification of given answer e.g. $\dfrac{\cos x\left(\sin^2 x+\cos^2 x\right)}{\sin^2 x-\cos^2 x} = \dfrac{\cos x}{\sin^2 x-\cos^2 x}$ oe	**A1**	All steps correct and final step justified $\dfrac{1}{\cos x}\times\dfrac{\cos^2 x}{\sin^2 x-\cos^2 x} = \dfrac{\cos x}{\sin^2 x-\cos^2 x}$ oe
8(b)	$2\cos^2 x+\cos x-1[=0]$	**B2**	**B1** for $\cos x = 1-\cos^2 x-\cos^2 x$ or better
	$(2\cos x-1)(\cos x+1)[=0]$	**M1**	**FT** *their* 3-term quadratic in cos$x$
	$[x =]\ 60°, 300°, 180°$ and no extras in range	**A2**	**A1** for any two correct , ignoring extras

Question	Answer	Marks	Guidance
9(a)	Derivative of e^{2x} : $2e^{2x}$ soi	**B1**	
	$x \times 2e^{2x} + e^{2x}$ isw	**B1**	**FT** *their* $2e^{2x}$
9(b)	$[\text{When } x = 1]\ y = e^2$	**B1**	
	[gradient tangent =] *their* $\left.\frac{dy}{dx}\right\|_{x=1}$	**B1**	**FT** *their* derivative which must include at least one term in e^{2x}
	Gradient of normal = $\frac{-1}{their(3e^2)}$	**B1**	**FT** $\frac{-1}{their \left.\frac{dy}{dx}\right\|_{x=1}}$
	$y - e^2 = \frac{-1}{3e^2}(x - 1)$ oe, isw	**B1**	**dep** on 2 marks awarded in part (a) and all previous marks awarded in this part
9(c)	$\left[xe^{2x} - \frac{1}{2}e^{2x}\right]_0^2$	**M3**	**M2** for $xe^{2x} + ke^{2x}$ where $k < 0$ or $k = \frac{1}{2}$ or **M1** for $\int 2xe^{2x}dx = xe^{2x} - \int e^{2x}dx$
	$\left(2e^4 - \frac{1}{2}e^4\right) - \left(-\frac{1}{2}\right)$	**A1**	
	$1.5e^4 + 0.5$ or exact equivalent	**A1**	
10(a)	$a + 4d = 11$ oe	**B1**	
	$a + 6d = 3(a + d)$ oe	**B1**	
	Correctly eliminates one unknown and solves for a or d	**M1**	**FT** *their* linear equations in a and d providing **B1** earned.
	$d = 2,\ a = 3$	**A1**	

Question	Answer	Marks	Guidance
10(b)	$3+d=3r^2$	**B1**	
	$3+5d=3r^4$	**B1**	
	$3+5d=3\left(\frac{3+d}{3}\right)^2$ oe or $3+5\left(3r^2-3\right)=3r^4$ oe	**M1**	
	$d^2-9d[=0]$ or $3r^4-15r^2+12[=0]$	**A1**	
	d = 9 and r = 2 and no other values	**A2**	**A1** for d = 9 and no other value of d or for r = 2 and no other value of r