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

Question	Answer	Marks	Guidance
5(b)	Correct derivative: $4\pi r - \frac{2000}{r^2}$ oe, isw	**B2**	**B1** for one correct term
	$4\pi r - \frac{2000}{r^2} = 0$ and solves for r	**M1**	**FT** *their* derivative providing that at least one term is correct
	$r = \sqrt[3]{\frac{2000}{4\pi}}$ oe, isw or 5.42 or 5.419[26…] rot to 3 or more dp	**A1**	
	Second derivative $\frac{\mathrm{d}^2S}{\mathrm{d}r^2} = 4\pi + 4000r^{-3}$ **and** When $r = 5.42$, $\frac{\mathrm{d}^2S}{\mathrm{d}r^2} > 0$ oe [hence minimum] or $4\pi + 4000(5.42)^{-3} > 0$ oe [hence minimum] or $\frac{\mathrm{d}^2S}{\mathrm{d}r^2} = 12\pi$ or 37 to 38 [hence minimum] or as $r > 0$, $\frac{\mathrm{d}^2S}{\mathrm{d}r^2} > 0$ [hence minimum] OR correctly finds the values of the first derivative at 5.42 oe ± h, where h is small [hence minimum]	**A1**	**Dep** on previous mark
6(a)	Velocity: $\frac{8t}{4t^2-5} - 1$	**B2**	**B1** for $\frac{\mathrm{f}(t)}{4t^2-5} - 1$ or for $\frac{8t}{4t^2-5} + \mathrm{g}(t)$
	Correct structure of quotient rule or equivalent product rule	**M1**	**FT** *their v* if possible; must be of equivalent difficulty
	Acceleration: $\frac{(4t^2-5)(8)-(8t)(8t)}{(4t^2-5)^2}$ oe, isw	**A1**	**FT** $\frac{8t}{4t^2-5} + k$ 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)	$\frac{(4\times 2.5^2-5)(8)-(8\times 2.5)(8\times 2.5)}{(4\times 2.5^2-5)^2}$ oe, soi	**M1**	Substitutes a value of $t > 2$ in an expression for a which has at least one term with a factor of $\frac{1}{(4t^2-5)^2}$ or $\frac{1}{16t^4-40t^2+25}$
	$a = -\frac{3}{5}$ oe only	**A1**	