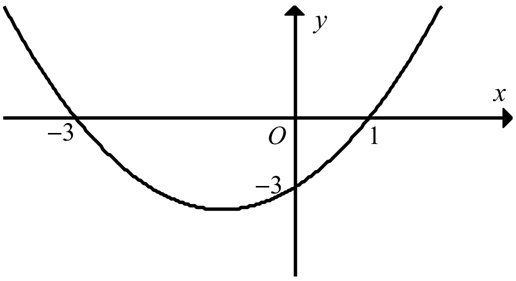
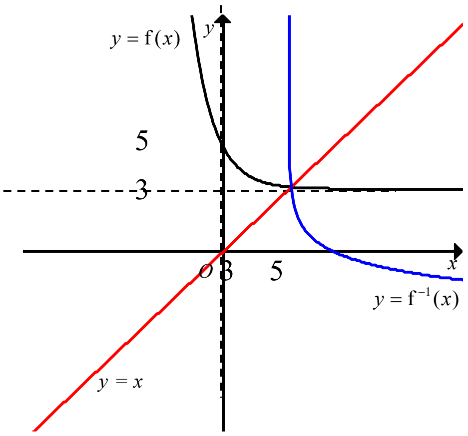
Question	Answer	Marks	Partial Marks
1(a)	$(x+1)^2-4$ oe $(-1,\ -4)$	**B3**	**B2** $y=(x+1)^2-4$ oe or **B1** $y=(x+1)^2+k$, where k is a constant
1(b)	Correct curve 	**B2**	**B1** for correct shape in 4 quadrants with minimum in the 3rd quadrant **B1** for an attempt at a quadratic graph with intercepts marked at –3 on the y-axis and –3 and 1 on the x-axis
2	$(3k-2)^2-4(2)(k)[*0]$	**M1**	Uses b^2-4ac * could be any inequality sign or =
	$9k^2-20k+4[*0]$	**A1**	Correctly simplifies to 3-term quadratic
	$(9k-2)(k-2)$	**M1**	**FT** Factorises or solves *their* 3-term quadratic
	Critical values $\frac{2}{9}$, 2	**A1**	
	$k<\frac{2}{9}$ $k>2$	**A1**	Mark final answer
3(a)	103 680	**2**	**M1** for $k\times 5!\times 4!\times 3!$ where $k=1, 2, 3, 6$
3(b)	270	**3**	**M2** for ${}^5C_1\times{}^4C_2\times{}^3C_1+{}^5C_1\times{}^4C_1\times{}^3C_2+$ ${}^5C_2\times{}^4C_1\times{}^3C_1$ oe OR **M1** for at least one correct product If 0 scored then **SC1** for a <u>final</u> answer of 540 or 264

Question	Answer	Marks	Partial Marks
4	$m_{AB} = \frac{-9-3}{6--4}$ oe isw or $-\frac{6}{5}$	**M1**	
	$[m_{\perp} =]\ \frac{5}{6}$ or $\frac{-1}{their\ m_{AB}}$	**M1**	**FT** *their* m_{AB} providing that $\frac{\text{difference in } y}{\text{difference in } x}$ attempted
	[Midpoint] $\left(\frac{-4+6}{2}, \frac{3-9}{2}\right)$ oe isw or $(1, -3)$	**M1**	
	Finds equation of perpendicular bisector: $y - their\ (-3) = -\frac{1}{their\left(-\frac{6}{5}\right)}(x - their\ 1)$ oe	**M1**	**FT** *their* perpendicular gradient providing gradient is $\frac{-1}{their\ m_{AB}}$ and using *their* midpoint *Their* midpoint must not be any of A, B, C or D
	$11x - 75 = \frac{5}{6}x - \frac{23}{6}$	**M1**	Eliminates one variable **dep** on previous **M** mark $11x - 75 =$ *their* perp bisector equation
	$E(7, 2)$	**A1**	
	[Area CDE =] 40	**A1**	Dependent on all previous marks
5	$\frac{dy}{dx} = 2x\tan\frac{x}{2} + \frac{x^2}{2}\sec^2\frac{x}{2}$ oe	**2**	**B1** for $\frac{d}{dx}\left(\tan\frac{x}{2}\right) = \frac{1}{2}\sec^2\frac{x}{2}$ soi or **M1 FT** for a product rule of correct structure with *their* $\frac{d}{dx}\left(\tan\frac{x}{2}\right)$
	$\frac{\delta y}{h} = their\left.\frac{dy}{dx}\right\|_{x=\frac{\pi}{3}}$ or $their\left.\frac{dy}{dx}\right\|_{x=\frac{\pi}{3}} \times h$	**M1**	Correct small changes relationship
	$1.94h$	**A1**	Dependent on **B2**
6(a)	$(3x + 2)^{10}$ oe	**M2**	**M1** for $(3x + 2)^2$ soi
	$1024 + 15\,360x + 103\,680x^2$	**A2**	**A1** for any two terms correct or $2^{10} + 10(2^9)(3x) + 45(2^8)(3x)^2$ or for 3 correct terms seen but not summed e.g. a list After **M2 A0**, allow **SC1** for an answer of $59\,049x^{10} + 393\,660x^9 + 1\,180\,980x^8$

Question	Answer	Marks	Partial Marks
6(b)	51 963 120	2	**M1** for ${}^{12}C_4\left(\frac{6}{x^2}\right)^8\left(\frac{x^4}{2}\right)^4$ soi
7(a)	Correct pair of graphs with **both** asymptotes and **both** intercepts correctly shown 	4	**B1** for correct shape for f; must have positive y-intercept and appear to tend to an asymptote in the 1st quadrant **B1** for (0, 5) indicated; must have attempted correct shape for f **B1** for asymptote at $y = 3$; must have attempted correct shape for f **B1** for a correct reflection of *their* f in the line $y = x$ $y = x$ does not have to be drawn **Maximum of B3 if not fully correct**
7(b)	$e^y = \frac{3}{2-x} - 2$ oe OR $e^x = \frac{3}{2-y} - 2$ oe and variables swapped at some point	M1	Rearranges to $e^y = \ldots$ e.g. $e^y = \frac{2x-1}{2-x}$ or $e^y = \frac{1-2x}{x-2}$ or $e^y = \frac{-3}{x-2} - 2$
	$\ln\left(\frac{3}{2-x} - 2\right)$ oe, isw	A1	
	$1 \leqslant x < 2$	B2	**B1** $x \geqslant 1$ oe OR $x < 2$ oe OR $1 < x \leqslant 2$
8(a)	$\cos x = 0$ or $\tan x = \frac{3}{2}$ oe	M1	
	[$x =$] $\frac{\pi}{2}$ or 1.57[07...] 0.983 or 0.9827[93…]	A2	and no extra solutions in range **A1** for either ignoring extras
8(b)	$\frac{2}{\sin(2\theta+1)} - 12\sin(2\theta+1) = 5$ or $2\operatorname{cosec}(2\theta+1) - \frac{12}{\operatorname{cosec}(2\theta+1)} = 5$	M1	• Writes in terms of cosec(2θ+1) or sin(2θ+1) only.

Question	Answer	Marks	Partial Marks
	$12\sin^2(2\theta+1)+5\sin(2\theta+1)-2\left[=0\right]$ or $2\text{cosec}^2(2\theta+1)-5\text{cosec}(2\theta+1)-12\left[=0\right]$ oe	**A1**	
	$4\sin(2\theta + 1) - 1)(3\sin(2\theta + 1) + 2)$ [= 0] or $(2\text{cosec}(2\theta + 1) + 3)(\text{cosec}(2\theta + 1) - 4)$ [= 0]	**M1**	Factorises or solves *their* 3-term quadratic in $\sin(2\theta+1)$ or $\text{cosec}(2\theta+1)$ **dep** on previous **M1**
	$2\theta+1$ = 0.253 or 0.2526[80…] OR $2\theta+1$ = – 0.73[0] or – 0.7297[27…] OR $2\theta+1 = \sin^{-1}\left(their\,\frac{1}{4}\right)$ OR $2\theta+1 = \sin^{-1}\left(their\,-\frac{2}{3}\right)$	**M1**	**dep** on previous **M1** **FT** providing $-1 \leqslant their\,\frac{1}{4} \leqslant 1$ and/or $-1 \leqslant their\,-\frac{2}{3} \leqslant 1$
	– 0.374 or – 0.3736[59…] 0.944 or 0.9444[56…] – 0.865 or – 0.8648[63…] 1.44 or 1.435[66…]	**A2**	and no extra solutions in range **A1** for two correct solutions ignoring extras in range
9(a)	135π isw or 424 or 424.1 to 424.2	**2**	**M1** for $\frac{1}{2}\times15^2\times\frac{6\pi}{5}$ oe
9(b)	18π or 56.5 to 56.6	**2**	**M1** for $15\times\frac{6\pi}{5}$ oe
9(c)	radius = 9, height = 12	**2**	**B1** for radius = 9 OR **M1** for a correct Pythagoras' statement e.g. *their* r^2 + height^2 = 15^2
9(d)(i)	$r=\frac{3}{4}h$ oe	**B1**	

Question	Answer	Marks	Partial Marks
9(d)(ii)	$V = \frac{1}{3}\pi\left(\frac{3}{4}h\right)^2 \times h$ oe	**B1**	**FT** *their* $r = kh$ where k is a positive constant e.g. $V = \frac{1}{3}\pi(\textit{their}\ kh)^2 \times h$
	$\frac{\mathrm{d}V}{\mathrm{d}h} = \frac{9\pi h^2}{16}$ oe	**B1**	**FT** *their* k where k is a positive constant e.g. $\frac{\mathrm{d}V}{\mathrm{d}h} = (\textit{their}\ k)^2\ \pi \times h^2$
	Relevant, correct chain rule **including** $\frac{\mathrm{d}h}{\mathrm{d}t}$ soi $\frac{\mathrm{d}h}{\mathrm{d}t} = \frac{\mathrm{d}V}{\mathrm{d}t} \times \frac{\mathrm{d}h}{\mathrm{d}V}$ oe	**B1**	e.g. $\frac{\mathrm{d}h}{\mathrm{d}t} = \frac{\mathrm{d}V}{\mathrm{d}t} \div \frac{\mathrm{d}V}{\mathrm{d}h}$
	$27 \times \frac{16}{9\pi \times 16}$ oe	**M1**	
	0.955 or 0.9549[29…]	**A1**	
10(a)(i)	$[v =]\frac{t^3}{3} - 2t \quad (+c)$	**M1**	Or $\left[\frac{t^3}{3} - 2t\right]_{[3]}^{[4]}$
	$[v =]\frac{t^3}{3} - 2t - \frac{10}{3}$	**A1**	Or substituting in limits $\left(\frac{4^3}{3} - 2\times 4\right) - \left(\frac{3^3}{3} - 2\times 3\right) - \frac{1}{3}$
	$v = 10$	**A1**	
10(a)(ii)	2 correct terms in $[s =]\frac{t^4}{12} - t^2 - \frac{10}{3}t\ (+d)$	**M1**	**FT** an expression in form $at^3 + bt$ Or 2 correct terms in $\left[\frac{t^4}{12} - t^2 - \frac{10}{3}t\right]_{[3]}^{[4]}$ 1
	$s = \frac{t^4}{12} - t^2 - \frac{10}{3}t + 12$	**A1**	**A1** substituting in limits $\left(\frac{4^4}{12} - 4^2 - \frac{10}{3}\times 4\right) - \left(\frac{3^4}{12} - 3^2 - \frac{10}{3}\times 3\right) - \frac{1}{4}$
	$s = 4$	**A1**	

Question	Answer	Marks	Partial Marks
10(b)	$[v=]19t+\frac{5}{2}e^{8-2t}(+c)$ oe	**M1**	
	$[v=]19t+\frac{5}{2}e^{8-2t}-\frac{137}{2}$ oe	**A1**	**FT** (*their* 10) – 78.5
	$[s=]\frac{19t^2}{2}-\frac{5}{4}e^{8-2t}-\frac{137}{2}t(+d)$ oe	**M1**	**dep** on previous **M1** **FT** *their* $-\frac{137}{2}$ provided not 0 or algebraic
	$[s=]\frac{19t^2}{2}-\frac{5}{4}e^{8-2t}-\frac{137}{2}t+\frac{509}{4}$ oe, cao	**A1**	
	$s = 392$ or 392.2[49…]	**A1**	
11(a)	$ar+ar^2=168$ or $ar^3+ar^4=94.5$ oe soi	**B1**	
	$\frac{ar^3(1+r)}{ar(1+r)}=\frac{94.5}{168}$ oe	**M1**	Correct equation where *a* can be directly eliminated
	$168r^2 = 94.5$ oe	**M1**	
	$r=\frac{3}{4}$ only nfww	**A1**	
	$\frac{3}{4}a+\frac{9}{16}a=168$ oe	**M1**	**FT** *their r*
	$a = 128$	**A1**	
	$u_6=\frac{243}{8}$ only oe, isw	**B1**	
11(b)	512	**B1**	