Question	Answer	Marks	Guidance
1	$(3k)^2 - 4\times 2\times k$	**M1**	Attempt $b^2 - 4ac$
	$9k^2 - 8k > 0$ soi Allow $9k^2 - 8k \geqslant 0$	**A1**	Must involve correct inequality. Can be implied by correct answers
	0, 8/9 soi	**A1**	
	$k < 0$, $k > 8/9$ (or 0.889)	**A1**	Allow $(-\infty, 0)$, $(8/9, \infty)$
	Total:	**4**	

Question	Answer	Marks	Guidance
2	$5C2\left(\frac{1}{ax}\right)^3\left(2ax^2\right)^2$ soi	**B1**	Seen or implied. Can be part of an expansion.
	$10\times\frac{1}{a^3}\times 4a^2 = 5$ soi	**M1A1**	M1 for identifying relevant term and equating to 5, all correct. Ignore extra x
	$a = 8$ cao	**A1**	
	Total:	**4**	

Question	Answer	Marks	Guidance
3(i)	$V = \frac{1}{12}h^3$ oe	**B1**	
	Total:	**1**	
3(ii)	$\frac{\mathrm{d}V}{\mathrm{d}h} = \frac{1}{4}h^2$ or $\frac{\mathrm{d}h}{\mathrm{d}V} = 4(12v)^{-2/3}$	**M1A1**	Attempt differentiation. Allow incorrect notation for M. For A mark accept *their* letter for volume - but otherwise correct notation. Allow V'
	$\frac{\mathrm{d}h}{\mathrm{d}t} = \frac{\mathrm{d}h}{\mathrm{d}V} \times \frac{\mathrm{d}V}{\mathrm{d}t} \quad = \frac{4}{h^2} \times 20$ soi	**DM1**	Use chain rule correctly with $\frac{\mathrm{d}(V)}{\mathrm{d}t} = 20$. Any equivalent formulation. Accept non-explicit chain rule (or nothing at all)
	$\left(\frac{\mathrm{d}h}{\mathrm{d}t}\right) = \frac{4}{10^2} \times 20 = 0.8$ or equivalent fraction	**A1**	
	Total:	**4**	

Question	Answer	Marks	Guidance
4(i)	$ABC = \pi/2 - \pi/7 = 5\pi/14$. $CBD = \pi - 5\pi/14 = 9\pi/14$	**B1**	**AG** Or other valid exact method.
	Total:	**1**	
4(ii)	$\sin\frac{\pi}{7} = \frac{½BC}{8}$ **or** $\frac{BC}{\sin\frac{2\pi}{7}} = \frac{8}{\sin\frac{5\pi}{14}}$ **or** $BC^2 = 8^2 + 8^2 - 2(8)(8)\cos\frac{2\pi}{7}$	**M1**	
	$BC = 6.94(2)$	**A1**	
	arc CD = *their* $6.94 \times 9\pi/14$	**M1**	Expect 14.02(0)
	arc $CB = 8 \times 2\pi/7$	**M1**	Expect 7.18(1)
	perimeter = 6.94 + 14.02 + 7.18 = 28.1	**A1**	
	Total:	**5**	

Question	Answer	Marks	Guidance
5(i)	$\tan x = \cos x \rightarrow \sin x = \cos^2 x$	**M1**	Use tan = sin/cos and multiply by cos
	$\sin x = 1 - \sin^2 x$	**M1**	Use $\cos^2 x = 1 - \sin^2 x$
	$\sin x = 0.6180$. Allow $(-1 + \sqrt{5})/2$	**M1**	Attempt soln of quadratic in $\sin x$. Ignore solution –1.618. Allow x = 0.618
	x-coord of $A = \sin^{-1} 0.618 = 0.666$ cao	**A1**	Must be radians. Accept 0.212π
	Total:	**4**	
5(ii)	***EITHER*** x-coord of B is $\pi - \textit{their}\, 0.666$	**(M1**	Expect 2.475(3). Must be radians throughout
	y-coord of B is $\tan(\textit{their}\, 2.475)$ or $\cos(\textit{their}\, 2.475)$	**M1**	
	$x = 2.48$, $y = -0.786$ or -0.787 cao	**A1)**	Accept $x = 0.788\pi$
	OR y-coord of B is – (cos or tan (*their* 0.666))	**(M1**	
	x-coord of B is $\cos^{-1}(\textit{their}\, y)$ or $\pi + \tan^{-1}(\textit{their}\, y)$	**M1**	
	$x = 2.48$, $y = -0.786$ or -0.787	**A1)**	Accept $x = 0.788\pi$
	Total:	**3**	

Question	Answer	Marks	Guidance
6(i)	**BA** = **OA** – **OB** = –5**i** – **j** + 2**k**	**B1**	Allow vector reversed. Ignore label **BA** or **AB**
	OA.BA = –10 – 3 + 10 = –3	**M1**	soi by ±3
	$\|\mathbf{OA}\|\times\|\mathbf{BA}\| = \sqrt{2^2+3^2+5^2}\times\sqrt{5^2+1^2+2^2}$	**M1**	Prod. of mods for at least 1 correct vector or reverse.
	$\cos OAB = \frac{+/-3}{\sqrt{38}\times\sqrt{30}}$	**M1**	
	$OAB = 95.1^\circ$ (or 1.66^c)	**A1**	
	Total:	**5**	
6(ii)	$\Delta\, OAB = \frac{1}{2}\sqrt{38}\times\sqrt{30}\sin 95.1$. Allow $\frac{1}{2}\sqrt{38}\times\sqrt{74}\sin 39.4$	**M1**	Allow their moduli product from **(i)**
	= 16.8	**A1**	cao but <u>NOT</u> from sin 84.9 (1.482^c)
	Total:	**2**	

Question	Answer	Marks	Guidance
7(i)	$f'(x) = \left[\frac{3}{2}(4x+1)^{1/2}\right]$ [4]	**B1B1**	Expect $6(4x+1)^{1/2}$ but can be unsimplified.
	$f''(x) = 6\times 1/2\times(4x+1)^{-1/2}\times 4$	**B1√**	Expect $12(4x+1)^{-1/2}$ but can be unsimplified. Ft from *their* $f'(x)$.
	Total:	**3**	
7(ii)	f(2), $f'(2)$, $kf''(2) = 27, 18, 4k$ OR 12	**B1B1√B1√**	Ft dependent on attempt at differentiation
	$27/18 = 18/4k$ oe OR $kf''(2) = 12 \Rightarrow k = 3$	**M1A1**	
	Total:	**5**	

Question	Answer	Marks	Guidance
8(i)	$\text{gf}(x) = 3\left(2x^2+3\right)+2 = 6x^2+11$	**B1**	**AG**
	$\text{fg}(x) = 2\left(3x+2\right)^2+3$ Allow $18x^2+24x+11$	**B1**	ISW if simplified incorrectly. Not retrospectively from **(ii)**
	Total:	**2**	
8(ii)	$y = 2\left(3x+2\right)^2+3 \quad \Rightarrow 3x+2 = (\pm)\sqrt{(y-3)/2}$ oe	**M1**	Subtract 3;divide by 2;square root. Or *x*/*y* interchanged. Allow $\frac{\sqrt{y-3}}{2}$ for 1st M
	$\Rightarrow x = (\pm)\frac{1}{3}\sqrt{(y-3)/2}-\frac{2}{3}$ oe	**M1**	Subtract 2; divide by 3; Indep. of 1st M1. Or *x*/*y* interchanged.
	$\Rightarrow (\text{fg})^{-1}(x) = \frac{1}{3}\sqrt{(x-3)/2}-\frac{2}{3}$ oe	**A1**	Must be a function of *x*. Allow alt. method $\text{g}^{-1}\text{f}^{-1}(x)$ OR $18\left(x+\frac{2}{3}\right)^2+3 \Rightarrow (\text{fg})^{-1}(x) = \sqrt{\frac{x-3}{18}}-\frac{2}{3}$
	Solve *their* $(\text{fg})^{-1}(x) \geqslant 0$ or attempt range of fg	**M1**	Allow range $\geqslant 3$ for M only. Can be implied by correct answer or $x >$ 11
	Domain is $x \geqslant 11$	**A1**	
	Total:	**5**	

Question	Answer	Marks	Guidance
8(iii)	$6(2x)^2+11=2(3x+2)^2+3$	**M1**	Replace x with $2x$ in gf and equate to *their* fg(x) from (i). Allow $\underline{12}\,x^2+11=$
	$6x^2-24x=0$ oe	**A1**	Collect terms to obtain correct quadratic expression.
	$x=0$, 4	**A1**	Both required
	Total:	**3**	

Question	Answer	Marks	Guidance
9(i)	$\frac{dy}{dx}=2x-2$. At $x=2$, $m=2$	**B1B1**	Numerical m
	Equation of tangent is $y-2=2(x-2)$	**B1**	Expect y = 2x – 2
	Total:	**3**	
9(ii)	Equation of normal $y-2=-½(x-2)$	**M1**	Through (2, 2) with gradient = –1/m . Expect $y=-½x+3$
	$x^2-2x+2=-½x+3 \rightarrow 2x^2-3x-2=0$	**M1**	Equate and simplify to 3-term quadratic
	$x=-½$, $y=3¼$	**A1A1**	Ignore answer of (2, 2)
	Total:	**4**	

Question	Answer	Marks	Guidance
9(iii)	At $x = -½$, grad $= 2(-½) - 2 = -3$	**B1**√	Ft *their* $-½$.
	Equation of tangent is $y - 3¼ = -3(x + ½)$	***M1**	Through *their B* with grad *their* -3 (not m_1 or m_2). Expect $y = -3x + 7/4$
	$2x - 2 = -3x + 7/4$	**DM1**	Equate *their* tangents or attempt to solve simultaneous equations
	$x = 3/4$, $y = -½$	**A1**	Both required.
	Total:	**4**	

Question	Answer	Marks	Guidance
10(i)	$2x - 2/x^3 = 0$	**M1**	Set = 0.
	$x^4 = 1 \Rightarrow x = 1$ at A cao	**A1**	Allow 'spotted' $x = 1$
	Total:	**2**	
10(ii)	$f(x) = x^2 + 1/x^2 (+c)$ cao	**B1**	
	$\frac{189}{16} = 16 + 1/16 + c$	**M1**	Sub $(4, \frac{189}{16})$. c must be present. Dep. on integration
	$c = -17/4$	**A1**	
	Total:	**3**	

Question	Answer	Marks	Guidance
10(iii)	$x^2+1/x^2-17/4=0 \Rightarrow 4x^4-17x^2+4\ (=0)$	**M1**	Multiply by $4x^2$ (or similar) to transform into 3-term quartic.
	$(4x^2-1)(x^2-4)\ (=0)$	**M1**	Treat as quadratic in x^2 and attempt solution or factorisation.
	$x=½,\ 2$	**A1A1**	Not necessary to distinguish. Ignore negative values. No working scores 0/4
	Total:	**4**	
10(iv)	$\int(x^2+x^{-2}-17/4)\mathrm{d}x\ =\ \frac{x^3}{3}-\frac{1}{x}-\frac{17x}{4}$	**B2,1,0**	Mark final integral
	$(8/3-1/2-17/2)-(1/24-2-17/8)$	**M1**	Apply *their* limits from **(iii)** (Seen). Dep. on integration of at least 1 term of y
	Area = $9/4$	**A1**	Mark final answer. $\int y^2$ scores 0/4
	Total:	**4**	