1	$\tan 2x = 2$ $2x = 63.4$ or 243.4 $x = 31.7$ or 121.7 (allow 122)	M1 A1 A1A1$\checkmark$ [4]	1 solution sufficient For 2nd A1 allow 90 + 1st soln prov. only 2 solns in range. Alt methods possible
2	$[7C3] \times [(2x^3)^4] \times [(-1/x^2)^3]$ **seen** soi $35 \times 2^4 \times (-1)^3$ leading to their answer soi $-560(x^6)$ as answer	B1B1 B1 B1 [4]	2 elements correct, 3rd element correct 2 elements correct. Identifying reqd term SC B3 for $[560(x)^6]$ as answer
3	AQ (or r) $= \sqrt{3}$ Area $\Delta = \sqrt{3}$ (or area Δ AQC $= \frac{\sqrt{3}}{2}$) Area sector $APR = \frac{1}{2}\left(\sqrt{3}\right)^2 \times \frac{\pi}{3} = \frac{\pi}{2}$ Shaded region $= \sqrt{3} - \frac{\pi}{2}$ oe cao	B1 B1$\checkmark$ M1A1$\checkmark$ A1 [5]	soi Allow 1.73 soi ft *their* $\sqrt{3}$ Allow 1.73 ft *their* $\sqrt{3}$. Allow 1.57. SCA1 for $\pi/4$ from $\frac{1}{2}\left(\sqrt{3}\right)^2 \times \frac{\pi}{6}$ provided $\Delta = \frac{\sqrt{3}}{2}$
4	$1000k = 3.2 \Rightarrow k = \frac{3.2}{1000}$ or $\frac{2}{625}$ or 0.0032 oe $\left(\frac{dM}{dr}\right) = 3kr^2$ $\frac{dM}{dt} = \frac{dM}{dr} \times \frac{dr}{dt}$ **used** e.g. $3 \times k \times 10^2 \times 0.1$ 0.096	M1A1 B1 M1 A1 [5]	Must eventually make dM/dt subject cao. Non-calculus methods (e.g. → 0.09696) can score only 1st 2 marks
5	**(i)** $6x + 2 = 7\sqrt{x} \Rightarrow 6\left(\sqrt{x}\right)^2 - 7\sqrt{x} + 2 = 0$ $\left(3\sqrt{x} - 2\right)\left(2\sqrt{x} - 1\right) = 0$ $\sqrt{x} = \frac{2}{3}$ or $\frac{1}{2}$ $x = \frac{4}{9}$ or $\frac{1}{4}$ (or 0.444, 0.25) **OR** $(6x+2)^2 = 49x \to 36x^2 - 25x + 4 = 0$ $(9x-4)(4x-1) = 0$ $x = \frac{4}{9}$ or $\frac{1}{4}$ (or 0.444, 0.25) oe	M1 M1 A1 A1 M1A1 M1 A1 [4]	Expressing as a clear quadratic soi oe e.g. $(3t-2)(2t-1) = 0$ 1 solution sufficient. Accept e.g. $t = 2/3$ Both solutions required cao Attempt to square both sides Attempt to solve (or formula etc.)
	(ii) $7^2 - 4 \times 6 \times k (= 0)$ $k = \frac{49}{24}$ or 2.04 **OR** $\frac{d}{dx}\left(7x^{\frac{1}{2}}\right) = \frac{d}{dx}(6x+k) \to \frac{7}{2}x^{\frac{-1}{2}} = 6$ $x = \frac{49}{144}$, $y = \frac{49}{12} \to k = \frac{49}{24}$ or 2.04	M1 A1 M1 A1 [2]	Apply $b^2 - 4ac (= 0)$ Attempt to equate derivatives

6 **(i)** $2p^2 - 2p + 2 + 12p + 6 \to 2p^2 + 10p + 8$	**M1**	Correct method for scalar product
u.v = 0	**B1**	Scalar product = 0
$(p+1)(p+4) = 0 \to p = -1$ **or** $p = -4$	**A1** **[3]**	cao Both solutions required
(ii) **u.v** = 2 + 0 + 18 = 20	**M1**	Use of $x_1x_2 + y_1y_2 + z_1z_2$
$\lvert \mathbf{u} \rvert = \sqrt{41}$ or $\lvert \mathbf{v} \rvert = \sqrt{13}$	**M1**	Correct method for moduli
$20 = \sqrt{41} \times \sqrt{13} \times \cos\theta$ oe	**M1**	All connected correctly
$\theta = 30.0°$ or 0.523 rads	**A1** **[4]**	cao
7 **(a)** $S_{10} = \dfrac{10}{2}[2 + 9(\cos^2 x - 1)]$	**M1**	Correct formula with $d = \pm(\cos^2 x - 1)$
$S_{10} = 5[2 - 9\sin^2 x]$	**M1**	Use of $c^2 + s^2 = 1$ in a correct S_{10}
$S_{10} = 10 - 45\sin^2 x$	**A1** **[3]**	Or $a = 10$, $b = 45$
(b) **(i)** $(0 <)\dfrac{1}{3}\tan^2\theta < 1$ oe	**M1**	Allow ≤
$(0 <)\theta < \dfrac{\pi}{3}$	**A1** **[2]**	cao Allow ≤
(ii) $S_\infty = \dfrac{1}{1 - \frac{1}{3}\tan^2\frac{\pi}{6}}$	**M1**	
$S_\infty = \dfrac{9}{8}$ or 1.125	**A1** **[2]**	cao
8 **(i)** $(x-2)^2 - 4 + k$	**B1B1** **[2]**	$a = -2$, $b = -4$
(ii) f(x) ≥ $k - 4$ or [k – 4, ∞] or (k – 4, ∞) oe	**B1√** **[1]**	ft *their* $k - 4$. Accept >
(iii) smallest value of $p = 2$	**B1√** **[1]**	ft *their* 2
(iv) $x - 2 = (\pm)\sqrt{y + 4 - k}$	**M1**	
$x = 2 + \sqrt{y + 4 - k}$	**A1√**	ft from *their* part **(i)**
$f^{-1}(x) = 2 + \sqrt{x + 4 - k}$	**A1**	cao
Domain is x ≥ $k - 4$ or [k – 4, ∞] or (k – 4, ∞) oe	**B1√** **[4]**	ft from *their* part **(ii)**. Accept >

9 **(i)** $M = (1, 4)$ gradient $= \frac{1}{2}$ soi	**B1B1**	
grad of $MB = -2$ soi	**M1**	Use of $m_1m_2 = -1$
Equation MB : $y - 4 = -2(x - 1)$	**A1**√	Or $y = -2x + 6$ ft on *their* ½ or M
When $y = 0$, $x = 3$ or B = (3, 0)	**A1**√ **[5]**	ft result of putting $y = 0$ into *their* eqn
(ii) grad of $AB = -\frac{2}{6}$; grad of $BC = \frac{6}{2}$ oe	**M1**√	At least one correct √
$m_1m_2 = -1 (\Rightarrow AB \perp AC)$	**A1** **[2]**	**AG** Allow omitted conclusion
(iii) $D = (-1, 8)$	**B1**	
$AD = \sqrt{40}$ or 6.32	**B1** **[2]**	
10 **(i)** $3x^2 - 4x + 1 (<) 5$	**M1**	Attempt differentiate & put 5 on RHS
$(3x + 2)(x - 2) < 0$	**M1**	Attempt to factorise or solve
$-\frac{2}{3} < x < 2$ or $\left[-\frac{2}{3}, 2\right]$ or $\left(-\frac{2}{3}, 2\right)$. Allow ≤	**A2** **[4]**	SC Allow A1 for $-\frac{2}{3}$ and 2 seen
(ii) $3x^2 - 4x + 1 = 0 \Rightarrow (3x - 1)(x - 1) = 0$	**M1**	Derivative = 0 & **<u>any</u>** attempt to solve
$x = \frac{1}{3}$ or 1	**A1**	Both
$y = \frac{4}{27}$ or 0	**A1**	Both
$f''(x) = 6x - 4 \to f''\left(\frac{1}{3}\right) = -2\ (< 0)$; $f''(1) = 2\ (>0)$	**M1**	Or other valid method
max at $\left(\frac{1}{3}, \frac{4}{27}\right)$; min at (1, 0) cao	**A1** **[5]**	Allow just x values or just y values given for identification

11 **(i)** $x = \frac{4}{y^2} - 1$	**B1** **[1]**	**AG** At least 1 step of working needed
(ii) $\int\left(\frac{4}{y^2} - 1\right)dy = \left[-\frac{4}{y} - y\right]$	**B1B1**	For $-\frac{4}{y}$, $-y$
Upper limit = 2	**B1**	
$\left[\left(-\frac{4}{2} - 2\right) - (-4 - 1)\right]$	**M1**	Apply limits 1 and *their* 2 'correctly'
1	**A1** **[5]**	SC B2 for $\int 2(x+1)^{-\frac{1}{2}}\,dx - 3 \to 1$
(iii) $(\pi)\int x^2\,dy = (\pi)\int\left(\frac{16}{y^4} - \frac{8}{y^2} + 1\right)dy$	**B1B1**	
$(\pi)\left[\frac{-16}{3y^3} + \frac{8}{y} + y\right]$	**B1**	
$(\pi)\left[\left(\frac{-16}{24} + 4 + 2\right) - \left(\frac{-16}{3} + 8 + 1\right)\right]$	**M1**	Apply limits 1 and *their* 2 'correctly'
$\frac{5\pi}{3}$	**A1** **[5]**	