1	$\mathrm{f}: x \mapsto 10-3x,\ \mathrm{g}: x \mapsto \dfrac{10}{3-2x}$,		
	$\mathrm{ff}(x) = 10-3(10-3x)$	B1	Correct unsimplified expression
	$\mathrm{gf}(2) = \dfrac{10}{3-2(10-3(2))}$ $(=-2)$	B1	Correct unsimplified expression with 2 in for x
	$x = 2$	B1 [3]	
2	$f'(x) = \dfrac{8}{(5-2x)^2}$		
	$f(x) = \dfrac{8(5-2x)^{-1}}{-1} \div -2\ (+c)$	B1 B1	Correct without (÷ by −2) An attempt at integration (÷ by−2)
	Uses $x = 2$, $y = 7$,	M1	Substitution of correct values into an integral to find c
	$c = 3$	A1 [4]	
3	$\overrightarrow{OA} = 2\mathbf{i} - 5\mathbf{j} - 2\mathbf{k}$ and $\overrightarrow{OB} = 4\mathbf{i} - 4\mathbf{j} + 2\mathbf{k}$.		
	$\overrightarrow{AB} = 2\mathbf{i} + \mathbf{j} + 4\mathbf{k}$ **or** $\overrightarrow{AC} = 4\mathbf{i} + 2\mathbf{j} + 8\mathbf{k}$	B1	
	$\overrightarrow{OC} = \overrightarrow{OA} + \overrightarrow{AC} = 6\mathbf{i} - 3\mathbf{j} + 6\mathbf{k}$	M1	correct method for $\overrightarrow{OC}$
	OR		
	$\begin{pmatrix}2\\1\\4\end{pmatrix} = \begin{pmatrix}x-4\\y+4\\z-2\end{pmatrix}$,	B1	
	$\overrightarrow{OC} = \begin{pmatrix}x\\y\\z\end{pmatrix} = \begin{pmatrix}6\\-3\\6\end{pmatrix}$	M1	
	OR		
	$\overrightarrow{OB} - \overrightarrow{OA} = \overrightarrow{OC} - \overrightarrow{OB}$ $\therefore \overrightarrow{OC} = 2\overrightarrow{OB} - \overrightarrow{OA}$	B1	
	$= \begin{pmatrix}8\\-8\\4\end{pmatrix} - \begin{pmatrix}2\\-5\\-2\end{pmatrix} = \begin{pmatrix}6\\-3\\6\end{pmatrix}$	M1	
	Unit vector = (Their $\overrightarrow{OC}$) ÷ (Mod their $\overrightarrow{OC}$)	M1	Divides by their mod of their $\overrightarrow{OC}$
	$= (6\mathbf{i} - 3\mathbf{j} + 6\mathbf{k}) \div 9$	A1 [4]	Correct unsimplified expression

4	(i)	$\left(x-\frac{2}{x}\right)^6$ Term is ${}_6C_3 \times (-2)^3 = (-)160$ -160	 **B1** **B1** [2]	 ±160 seen anywhere
	(ii)	$\left(2+\frac{3}{x^2}\right)\left(x-\frac{2}{x}\right)^6$ Term in $x^2 = {}_6C_2(-2)^2 x^2$ $= 60\ (x^2)$ Term independent of x: = 2 × (their−160) + 3 × (their 60) −140	 **B1** **B1** **M1** **A1** [4]	 ±60 seen anywhere Using 2 products correctly
5	(i)	$\tan\left(\frac{\pi}{3}\right) = \frac{AC}{2x}$ or $\cos\left(\frac{\pi}{3}\right)\left(=\sin\frac{\pi}{6}\right) = \frac{2x}{AB}$ $\rightarrow AC = 2\sqrt{3}x$ or $AB = 4x$ $AM = \sqrt{13\boldsymbol{x}^2}, \sqrt{13}\boldsymbol{x}, 3.61\boldsymbol{x}$	**B1** **M1A1** [3]	Either trig ratio Complete method.
	(ii)	$\tan(M\hat{A}C) = \frac{x}{\text{Their } AC}$ $\theta = \frac{1}{6}\pi - \tan^{-1}\frac{1}{2\sqrt{3}}$ **AG**	**M1** **A1** [2]	"Their AC" must be f(x), $\left(M\hat{A}C\right) \neq \theta$. Justifies $\frac{\pi}{6}$ and links MAC & θ
6	(i)	$PT = r\tan\alpha$ $QT = OT - OQ = \frac{r}{\cos\alpha} - r$ or $\sqrt{r^2 + r^2\tan^2\alpha} - r$ Perimeter = sum of the 3 parts including $r\alpha$	**B1** **B1** **B1** [3]	
	(ii)	Area of triangle = $\frac{1}{2}\times 10\times 10\tan\frac{\pi}{3}$ Area of sector = $\frac{1}{2}\times 10^2\times\frac{1}{3}\pi$ Shaded region has area 34 (2sf)	**M1** **M1** **A1** [3]	Correct formula used, $50\sqrt{3}, 86.6$ Correct formula used, $\frac{50\pi}{3}$, 52.36

7 (i)	$\frac{1+\cos\theta}{1-\cos\theta}-\frac{1-\cos\theta}{1+\cos\theta}\equiv\frac{4}{\sin\theta\tan\theta}$		
	LHS = $\frac{1+2c+c^2-(1-2c+c^2)}{(1-c)(1+c)}$	**M1**	Attempt at combining fractions.
	$=\frac{4c}{1-c^2}$	**A1 A1**	A1 for numerator. A1 denominator
	$=\frac{4c}{s^2}$		Essential step for award of A1
	$=\frac{4}{ts}$ **AG**	**A1** [4]	
(ii)	$\sin\theta\left(\frac{1+\cos\theta}{1-\cos\theta}-\frac{1-\cos\theta}{1+\cos\theta}\right)=3.$		Uses part (i) to eliminate "s" correctly.
	$\rightarrow s\times\frac{4}{ts}=3\ (\rightarrow t=\frac{4}{3})$	**M1**	
	$\theta=53.1°$ and $233.1°$	**A1 A1√** [3]	√ for 180° + 1st answer.
8	A (0, 7), B (8, 3) and C ($3k$, k)		
(i)	m of AB is −½ oe.	**B1**	Using A,B or C to get an equation
	Eqn of AB is $y=-\frac{1}{2}x+7$	**M1**	Using C or A,B in the equation
	Let $x=3k$, $y=k$	**M1**	
	$\boldsymbol{k=2.8}$ **oe**	**A1**	
	OR		
	$\frac{7-k}{0-3k}=\frac{3-k}{8-3k}$	**M1A1**	Using A,B & C to equate gradients
	$\rightarrow 20k=56\rightarrow k=2.8$	**DM1A1**	Simplifies to a linear or 3 term quadratic = 0.
	OR		
	$\frac{7-k}{0-3k}=\frac{7-3}{0-8}$	**M1A1**	Using A,B and C to equate gradients
	$\rightarrow 20k=56\rightarrow k=2.8$	**DM1A1** [4]	Simplifies to a linear or 3 term quadratic = 0.

(ii)	M(4, 5) Perpendicular gradient = 2. Perp bisector has eqn $y-5=2(x-4)$ Let $x = 3k$, $y = k$ $k=\frac{3}{5}$ oe **OR** $(0-3k)^2+(7-k)^2=(8-3k)^2+(3-k)^2$ $-14k+49=73-54k \rightarrow 40k=24 \rightarrow k=0.6$	**B1** **M1** **M1** **A1** **M1A1** **DM1A1** [4]	anywhere in (ii) Use of $m_1m_2=-1$ soi Forming eqn using their M and their "*perpendicular m*" Use of Pythagoras. Simplifies to a linear or 3 term quadratic = 0.
9 (i) (a)	$a+(n-1)d=10+29\times2$ = 68	**M1** **A1** [2]	Use of *n*th term of an AP with a=±10, d=±2, n=30 or 29 Condone – 68 → 68
(b)	$\frac{1}{2}n(20+2(n-1))=2000$ or 0 $\rightarrow 2n^2+18n-4000=0$ oe (n=) 41	**M1** **A1** **A1** [3]	Use of S_n formula for an AP with a=±10, d=±2 and equated to either 0 or 2000. Correct 3 term quadratic = 0.
(ii)	$r = 1.1$, oe Uses $S_{30}=\frac{10(1.1^{30}-1)}{1.1-1}$ (= 1645) Percentage lost = $\frac{2000-1645}{2000}\times100$ = 17.75	**B1** **M1** **DM1** **A1** [4]	e.g. $\frac{11}{10}$, 110% Use of S_n formula for a GP, a=±10, n=30. Fully correct method for % left with "their 1645" allow 17.7 or 17.8.
10	$y=\frac{8}{x}+2x.$		
(i)	$\frac{dy}{dx}=-8x^{-2}+2$ $\frac{d^2y}{dx^2}=16x^{-3}$ $\int y^2dx=-64x^{-1}$ oe+ $32x$ oe + $\frac{4x^3}{3}$ **oe** $(+c)$	**B1** **B1** **3 × B1** [5]	unsimplified ok unsimplified ok B1 for each term – unsimplified ok

(ii)	sets $\frac{dy}{dx}$ to 0 $\rightarrow x = \pm 2$ $\rightarrow M(2, 8)$ Other turning point is $(-2, -8)$ If $x = -2$, $\frac{d^2y}{dx^2} < 0$ ∴Maximum	**M1** **A1** **A1** **M1** **A1** [5]	Sets to 0 and attempts to solve Any pair of correct values A1 Second pair of values A1 Using their $\frac{d^2y}{dx^2}$ if kx^{-3} and $x< 0$
(iii)	Vol = π × [part (i)] from 1 to 2 $\frac{220\pi}{3}$, 73.3π, 230	**M1** **A1** [2]	Evidence of using limits 1&2 in their integral of y^2 (ignore π)
11	$f : x \mapsto 6x - x^2 - 5$		
(i)	$6x - x^2 - 5 \leqslant 3$ $\rightarrow x^2 - 6x + 8 \geqslant 0$ $\rightarrow x = 2, x = 4$ $x \leqslant 2, x \geqslant 4$ condone < and/or >	 **M1** **A1** **A1** [3]	 $\pm(6x - x^2 - 8) =, \leqslant, \geqslant 0$ and attempts to solve Needs both values whether =2, <2, >2 Accept all recognisable notation.
(ii)	Equate $mx + c$ and $6x - x^2 - 5$ Use of "$b^2 - 4ac$" $4c = m^2 - 12m + 16$. **AG** OR $\frac{dy}{dx} = 6 - 2x = m \rightarrow x = \left(\frac{6-m}{2}\right)$ $m\left(\frac{6-m}{2}\right) + c = 6\left(\frac{6-m}{2}\right) - \left(\frac{6-m}{2}\right)^2 - 5$ $4c = m^2 - 12m + 16$. **AG**	**M1** **DM1** **A1** **M1** **M1** **A1** [3]	Equates, sets to 0. Use of discriminant with values of $a.b.c$ independent of x. = (0) must appear before last line. Equates $\frac{dy}{dx}$ to m and rearrange Equates $mx + c$ and $6x - x^2 - 5$ and substitutes for x
(iii)	$6x - x^2 - 5 = 4 - (x - 3)^2$	**B1 B1** [2]	4 B1 – $(x - 3)^2$ B1
(iv)	$k = 3$.	**B1**√ [1]	√ for "b".
(v)	$g^{-1}(x) = \sqrt{4 - x} + 3$	**M1 A1** [2]	Correct order of operations. $\pm\sqrt{4-x} + 3$ M1A0 $\sqrt{x-4} + 3$ M1A0 $\sqrt{4-y} + 3$ M1A0