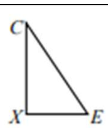
Use correct sector area formula	**M1**		Nov/9709/11/2024/Q3
Obtain $\frac{1}{2}\times 15^2\times\frac{2}{5}\pi - \frac{1}{2}\times x^2\times\frac{2}{5}\pi = \frac{209}{5}\pi$ or equivalent	**A1**		
Obtain $[x]=4$	**A1**	AWRT 4.00.	
Use correct arc length formula twice	**M1**		
Obtain $22+\frac{38}{5}\pi$	**A1**	OE. Must be in terms of π. Like terms must be collected. Not from a rounded value of x.	
	5		

[Perimeter =] $r+r\theta+r+2r\times 2\theta+r+r\theta+r$ $\quad [=4r+6r\theta]$	**B1**		Nov/9709/12/2024/Q6
[Area =] $\frac{1}{2}r^2\theta+\frac{1}{2}(2r)^2\times 2\theta+\frac{1}{2}r^2\theta$ $\quad [=5r^2\theta]$	**B1**		
$4r+6r\theta=14$ and $5r^2\theta=10$	**M1***	$ar+br\theta=14$ and $cr^2\theta=10$ where a, b and c are constants $\neq 0$. Terms may be uncollected.	
EITHER			
$5r^2\frac{14-4r}{6r}=10$ or $4r+6r\left(\frac{10}{5r^2}\right)=14$	**DM1**	Eliminate θ to get an equation in r.	
$[\Rightarrow 2r^2-7r+6=0\Rightarrow]\ (r-2)(2r-3)=0$	**DM1**	Factorise or other accepted method for solving their 3-term quadratic.	
OR			
$5\left(\frac{14}{4+6\theta}\right)^2\theta=10$ or $4\left(\sqrt{\frac{10}{5\theta}}\right)+6\left(\sqrt{\frac{10}{5\theta}}\right)\theta=14$	**DM1**	Eliminate r to get an equation in θ.	
$[\Rightarrow 18\theta^2-25\theta+8=0\Rightarrow]\ (9\theta-8)(2\theta-1)=0$	**DM1**	Factorise or other accepted method for solving their 3-term quadratic.	
Then			
$r=2$ and $\theta=0.5$	**B1**	Condone extra answers $r=\frac{3}{2}$ and $\theta=\frac{8}{9}$.	
	6		

(a)	Area of sector $BOF = \frac{1}{2}\times 20^2 \times (2\pi - 2.4)$ $[=776.63\ldots]$	M1	Or combination of large semi-circle and small sector: $\frac{1}{2}\times 20^2\times\pi + \frac{1}{2}\times 20^2 \times (\pi - 2.4)$.	Nov/ 9709/13/ 2024/ Q7
	Length $BD = DF = 2\times 20\sin 0.6$ or $\sqrt{20^2+20^2-2\times 20\times 20\cos 1.2}$ $[=22.58\ldots]$	M1*	Length of radius of small circles is acceptable for M1.	
	Area of two semicircles $= \pi\times(20\sin 0.6)^2$ $[=400.64\ldots]$	DM1		
	Area of triangles $= 2\times\frac{1}{2}\times 20\times 20\sin 1.2$ $[=372.81\ldots]$	M1		
	Total area = 1550[cm^2]	A1	Expect 1550.09 but accept AWRT to 3sf.	
		5		
(b)	$\frac{1}{2}\pi r^2 = 50\pi \Rightarrow r = 10$	B1	May be seen as $20\sin\frac{\theta}{2}$, where $\theta = \frac{\pi}{3}$.	
	$\Rightarrow \theta = \frac{\pi}{3}$	M1*	OE Finding θ using *their* r. Allow working in degrees.	
	Arc length of sector $BOF = 20\times\left(2\pi - \textit{their}\ \frac{2\pi}{3}\right)$	DM1		
	Total perimeter $= 20\times\left(2\pi - \textit{their}\ \frac{2\pi}{3}\right) + 2\pi\times \textit{their}\ 10$	DM1	Dependent on the first dM1.	
	$\frac{140\pi}{3}$ or $46\frac{2}{3}\pi$	A1	Must be a single exact term.	
		5		

(a)	Angle $\theta = \frac{\pi}{2} - \cos^{-1}\frac{10}{15}$ or $\sin^{-1}\frac{10}{15} = 0.7297$	B1	Condone working in degrees if converted to radians at th end. AG	June/ 9709/11/ 2024/ Q7
		1		
(b)	$BC = \sqrt{15^2 - 10^2}$ $[=11.18\ldots \text{ or } 5\sqrt{5}]$	B1		
	Arc $AB = 15\times 0.7297[=10.9455]$	B1		
	Perimeter = *their* BC + *their* arc AB + 25 + 5π	M1		
	Perimeter = 62.8	A1	AWRT	
	Area sector $AOB = \frac{1}{2}\times 15^2\times 0.7297[=82.09]$	B1		
	Area $= \frac{1}{2}\times 10\times \textit{their}\ BC$ + *their* sector AOB + $\frac{\pi}{4}\times 10^2$	M1		
	Area = 217	A1	AWRT	
		7		

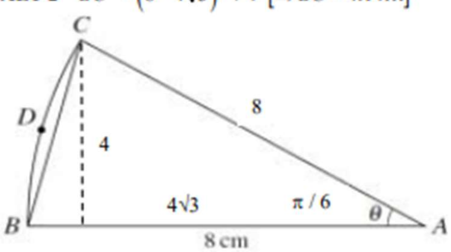
(a)(i)	 $X\hat{C}E = \frac{\pi}{6}$, $C\hat{E}X = \frac{\pi}{3}$			June/ 9709/12/ 2024/ Q8
	$\frac{XE}{0.4} = \sin\frac{\pi}{6}$ or $\frac{XE}{0.4} = \cos\frac{\pi}{3}$ $[XE = 0.2]$	M1	A correct trig expression involving XE. Do not condone a mixture of degrees and radians.	
	Length $EF = 2 + 2\times 0.2 = 2.4$	A1	AG	
		2		

(a)(ii)	$[CX =] 0.4\cos\frac{\pi}{6}$ or $0.4\sin\frac{\pi}{3}$ or $\sqrt{0.4^2 - 0.2^2}$	B1	OE, SOI Expect $\frac{\sqrt{3}}{5}$ or 0.3464.	
	$[\text{Sector} =] \frac{1}{2}\times(0.4)^2\times\frac{\pi}{3}$	B1	SOI Expect 0.0838 or $\frac{2\pi}{75}$. Allow use of $\frac{60}{360}\pi(0.4)^2$.	
	Either Area of *their* (rectangle + two triangles + two sectors) Or Area of *their* (trapezium + two sectors)	M1	Either implied by a correct answer or areas clearly labelled. Expect 0.6928 + 0.06928 + 0.1676 or $\frac{2\sqrt{3}}{5}+\frac{\sqrt{3}}{25}+\frac{4\pi}{75}$. Or 0.7621 + 0.1676 or $\frac{11\sqrt{3}}{25}+\frac{4\pi}{75}$.	
	0.930	A1	AWRT Condone $\frac{11\sqrt{3}}{25}+\frac{4\pi}{75}$.	
		4		
(b)	[Length AD =] $2+2r$	B1	Must be seen alone or part of a list and not part of a product.	
	[Arc length =] $r\times\frac{\pi}{3}$	B1	May be implied by $r\times\frac{\pi}{3}\times 2$. Must be seen alone or part of a list.	
	$[EF =] 2+2r\sin\frac{\pi}{6}$ or $2+2r\cos\frac{\pi}{3}$ or $2+r$	B1	Must be seen alone or part of a list and not part of a product.	
	$[4+3r+\frac{2\pi r}{3}=6$ leading to $]$ 0.393	B1	AWRT Condone $\frac{6}{2\pi+9}$. NB: Using $EF = 2.4$ gives 0.391.	
		4		
(a)	State $2r + r\theta = 65$ and $\frac{1}{2}r^2\theta = 225$	B1		June/ 9709/13/ 2024/ Q6
	Form a 3-term quadratic or cubic in r or θ or $r\theta$ from correct arc and sector formula	*M1	Condone sign errors.	
	Solve *their* 3 term quadratic or cubic to obtain values of r or θ	DM1	Expect $2r^2 - 65r + 450 = (2r-45)(r-10)$ or $18\theta^2 - 97\theta + 72 = (9\theta - 8)(2\theta - 9)$.	
	$r = 10$ and $\theta = 4.5$ ignore $r = 22.5$ and $\theta = \frac{8}{9}$, do not ignore $r = 0$	A1	**B1 SC** if no quadratic or cubic solution. If $r = 0$ included A0 or B0 SC.	
		4		
(b)	Use correct formula for area of triangle with clear use of angle being $2\pi -$ their θ	M1	Expect 1.783 or 102.2°, *their* θ must be reflex.	
	48.9	A1	AWRT, WWW or a second answer. Or greater accuracy; condone absence of units.	
		2		
(a)	$k = \frac{2}{3}$	B1	Allow ACB = $\frac{2\pi}{3}$.	Nov/9 709/11 / 2023/ Q6
		1		
(b)	Perimeter of shaded area $= 2\pi r$	B1		
		1		

(c)	Major sector $OAB = \frac{1}{2}r^2 \times \frac{4\pi}{3}$	*M1	Expect $\frac{2}{3}\pi r^2$. Finds area of any relevant sector or triangle. Can be embedded in segment formula.	
	One or both segments $= [2] \times \left(\frac{1}{2}r^2 \times \frac{\pi}{3} - \frac{1}{2}r^2 \sin\frac{\pi}{3}\right)$	*M1		
	$= [2]\left(r^2\frac{\pi}{6} - r^2\frac{\sqrt{3}}{4}\right)$	A1		
	Shaded area $= \frac{2}{3}\pi r^2 - 2\left(\frac{1}{6}\pi r^2 - \frac{r^2\sqrt{3}}{4}\right)$	DM1		
	$= \frac{\pi r^2}{3} + \frac{r^2\sqrt{3}}{2}$	A1		

(a)	[Arc length =] $2 \times \frac{\pi}{3}$ or $\frac{60}{360} \times 2\pi \times 2$	B1	Finding one correct arc length – may be implied by correct final answer.	Nov/9709/12/2023/Q4
	[Perimeter =] 2π or 6.28	B1	AWRT	
		2		
b)	[Area of one sector =] $\frac{1}{2} \times 2^2 \times \frac{\pi}{3}$ or $\frac{60}{360} \times \pi \times 2^2 \left[= \frac{2\pi}{3} \text{ or } 2.09\right]$	B1	SOI AWRT	
	[Area of triangle =] $\frac{1}{2} \times 2^2 \times \sin\left(\frac{\pi}{3}\right)$ or other valid method $\left[= \sqrt{3} \text{ or } 1.73\right]$	B1	AWRT Allow use of 60°	
	[Area of coin = 3 segments + triangle ⇒] $3\left(\frac{2\pi}{3} - \sqrt{3}\right) + \sqrt{3}$ [= 2.82]	M1	OE Or 3 sectors – 2 triangles $\left(3 \times \frac{2\pi}{3} - 2 \times \sqrt{3}\right)$ or Sector + 2 segments $\left(\frac{2\pi}{3} + 2\left(\frac{2\pi}{3} - \sqrt{3}\right)\right)$	
	$2\pi - 2\sqrt{3}$ or $2(\pi - \sqrt{3})$	A1	Must be one of these simplified versions but equivalent decimal answers can score B1B1M1	
		4		

	Answer	Marks	Guidance	
(a)	Angle $ACO = 0.7$	B1	Don't allow AWRT 0.7 .	Nov/9709/13/2023/Q10
		1		
(b)	$[R =]\ 1.53\,r$	B1	Allow AWRT 1.53*r*.	
		1		
(c)	Sector $OAB = \frac{1}{2}r^2 \times 2.8\ \left[= 1.4r^2\right]$	B1		
	Sector $CAB = \frac{1}{2}(\mathit{their}\ R)^2 \times 2 \times \mathit{their}\ 0.7$	*M1		
	$1.638\,r^2$	A1	Allow AWRT $1.64\,r^2$.	
	$[2]\times\frac{1}{2}r^2\sin(\pi - 1.4)$ OR $[2]\times\frac{1}{2}r \times \mathit{theirR}\sin 0.7$	*M1		
	$2\times 0.4927r^2$	A1	Allow AWRT $0.98\,r^2$ to $0.99\,r^2$.	
	$1.4r^2 - \left(\mathit{their}\,1.638r^2 - \mathit{their}\,0.985r^2\right)$	DM1		
	$0.747r^2$ to $0.748r^2$	A1		
		7		

Answer	Marks	Guidance	
$\frac{1}{2}\times 8^2 \times \theta = \frac{16\pi}{3} \Rightarrow \theta = \frac{\pi}{6}$	B1	SOI OE e.g. $\frac{2\pi}{12}$, 0.524(3s.f.) Use of degrees acceptable throughout provided conversion used in formulae for sector area and arc length.	June/9709/11/2023/Q4
Arc length $= 8\times \mathit{their}\frac{\pi}{6}$ [= 4.1887…]	M1	OE FT *their θ*. Look for $\frac{4\pi}{3}$.	
$[BC =]\ 2\times 8\sin\left(\frac{1}{2}\times \mathit{their}\frac{\pi}{6}\right)$ [= 4.1411…]	M1	Attempt to find BC or BC^2 (see alt. methods below FT *their θ*. Look for $16\sin\frac{\pi}{12}$ or $4\sqrt{6} - 4\sqrt{2}$.	
Perimeter = 8.33	A1	AWRT Must be combined into one term.	
ALT 1 $BC^2 = 8^2 + 8^2 - 2\times 8\times 8\cos\left(\mathit{their}\frac{\pi}{6}\right)[\Rightarrow BC = 4.14\ldots]$ **ALT 2** $BC^2 = \left(8 - 4\sqrt{3}\right)^2 + 4^2[\Rightarrow BC = 4.14\ldots]$  **ALT 3** $\frac{BC}{\sin\left(\frac{\pi}{6}\right)} = \frac{8}{\sin\left(\frac{5\pi}{12}\right)}[\Rightarrow BC = 4.14\ldots]$		ALT 1 Substitute into correct cosine rule. FT *their θ* Look for $128 - 64\sqrt{3}$ ALT 2 Find lengths 4 and $4\sqrt{3}$ then use Pythagoras in the left hand triangle. ALT 3 Substitute into correct sine rule.	
	4		

(a)	$\frac{1}{2}OA = x\cos\theta$ or $\frac{OA}{\sin(\pi - 2\theta)} = \frac{x}{\sin\theta}$ or $OA^2 = x^2 + x^2 - 2x^2\cos(\pi - 2\theta)$ or $x^2 = r^2 + x^2 - 2rx\cos\theta$ or other valid method.	*B1	Correct expression containing $\frac{1}{2}OA$, OA or OA^2 (allow p, a or r for OA) containing only terms with x and θ but not just $OA = 2x\cos\theta$. Do not condone $\sin\pi - 2\theta$ until missing brackets recovered or $\cos(180-2\theta)$ until it becomes $-cos2\theta$ etc.	June/9709/12/2023/Q6
	$OA = 2x\cos\theta$ leading to Arc length = $2x\theta\cos\theta$	DB1	AG Complete correct method showing all necessary working. Condone $2x\cos\theta \times \theta$.	
		2	If B0 but www then **SCB1** for $OA = 2x\cos\theta$ leading to Arc length = $2x\theta\cos\theta$.	
(b)	Sector area = $\frac{1}{2}(2x\cos\theta)^2 \times \theta$	M1	OE Using sector formula with a correct OA. Condone $cos\theta^2$ for $cos^2\theta$ and missing brackets.	
	Triangle area = $\frac{1}{2} \times 2x\cos\theta x\sin\theta$ OR $\frac{1}{2}x^2\sin(\pi - 2\theta)$	M1	Using a correct triangle formula for the correct triangle. Condone missing brackets and 180 for π.	
	[Area *APB* =] *Their* sector area – *their* triangle area	M1	Both expressions must be areas involving terms with x^2 and θ only. Condone missing brackets and 180 for π for the triangle. Condone calling the sector a segment.	
	[Area *APB* =] $\frac{1}{2}(2x\cos\theta)^2 \times \theta - \frac{1}{2}x^2\sin(\pi - 2\theta)$ [$= x^2(2\theta\cos^2\theta - \frac{1}{2}\sin 2\theta)$ or $x^2\cos\theta(2\theta\cos\theta - \sin\theta)$]	A1	OE A correct expression. Mark the first unsimplified result of subtraction and ISW any incorrect 'simplifications'.	
		4		
(a)	$\tan BDC = \frac{4}{3}$ or $\sin BDC = \frac{4}{5}$ or $\cos BDC = \frac{3}{5}$ **used** to find ADC	M1	May use cosine rule or $CAD = \tan^{-1}\frac{4}{8}$.	March/9709/12/2023/Q8
	$BDC = 0.927[3] \rightarrow ADC = \pi - 0.927[3]$ [= 2.214 to 2.215]	A1	Allow degrees, 126.87, and 0.7048 π or 0.705 π	
	$Arc\ AC = 5 \times their\ 2.214$	M1	Use of $r\theta$ or $\frac{\theta}{360}.2\pi r$ Expect 11.07 .	
	$AC = \sqrt{8^2 + 4^2}$ *or* $2 \times 5 \times \sin 1.107$	M1	Expect 8.94 .	
	[Perimeter = 11.07 + 8.94 =] 20.0	A1	Accept AWRT [20.01, 20.02].	
		5		
(b)	Sector $ACD = ½ \times 5^2 \times their\ 2.214$	M1	See use of $\frac{1}{2}r^2\theta$ or $\frac{\theta}{360}.\pi r^2$. Expect 27.7 .	
	Subtracting the area of $\Delta ADC = ½ \times 5 \times 4$ or $\frac{1}{2}5^2 \sin their\ 2.214$ or $\frac{1}{2} \times 8 \times 4 - \frac{1}{2} \times 3 \times 4$	M1	Subtracting the area of ΔADC, expect -10.	
	Shaded area = 27.7 − 10 = 17.7	A1	Accept AWRT [17.67, 17.68]. Correct answer cannot come from an angle of 2.215 .	
		3		