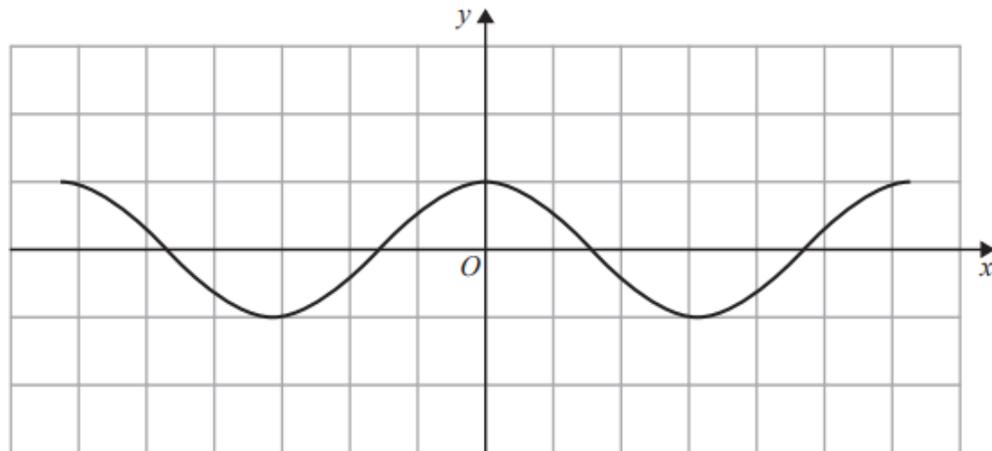


# Radians- Questions

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June 2019 Mathematics Advanced Paper 1: Pure Mathematics 1

1.



**Figure 1**

Figure 1 shows a plot of part of the curve with equation  $y = \cos x$  where  $x$  is measured in radians. Diagram 1, on the opposite page, is a copy of Figure 1.

(a) Use Diagram 1 to show why the equation

$$\cos x - 2x - \frac{1}{2} = 0$$

has only one real root, giving a reason for your answer.

**(2)**

Given that the root of the equation is  $\alpha$ , and that  $\alpha$  is small,

(b) use the small angle approximation for  $\cos x$  to estimate the value of  $\alpha$  to 3 decimal places.

**(3)**

2.

Given that  $\theta$  is small and is measured in radians, use the small angle approximations to find an approximate value of

$$\frac{1 - \cos 4\theta}{2\theta \sin 3\theta}$$

(3)

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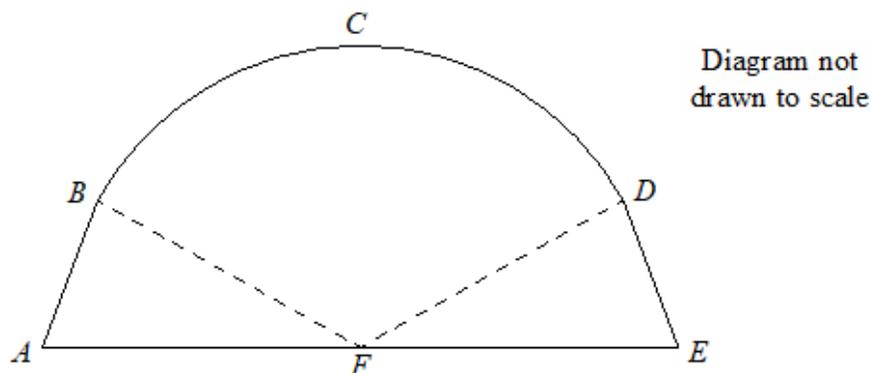


Figure 1

Figure 1 is a sketch representing the cross-section of a large tent  $ABCDEF$ .

$AB$  and  $DE$  are line segments of equal length.

Angle  $FAB$  and angle  $DEF$  are equal.

$F$  is the midpoint of the straight line  $AE$  and  $FC$  is perpendicular to  $AE$ .

$BCD$  is an arc of a circle of radius 3.5 m with centre at  $F$ .

It is given that

$$AF = FE = 3.7 \text{ m}$$

$$BF = FD = 3.5 \text{ m}$$

$$\text{angle } BFD = 1.77 \text{ radians}$$

Find

- (a) the length of the arc  $BCD$  in metres to 2 decimal places, (2)
- (b) the area of the sector  $FBCD$  in  $\text{m}^2$  to 2 decimal places, (2)
- (c) the total area of the cross-section of the tent in  $\text{m}^2$  to 2 decimal places. (4)

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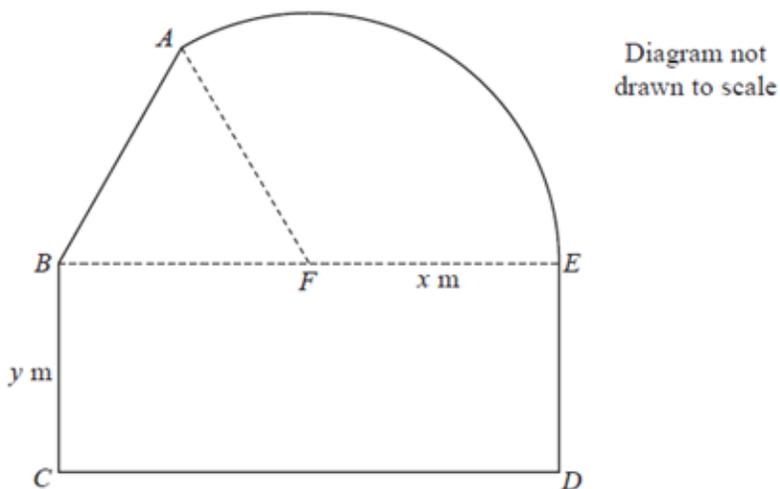


Figure 4

Figure 4 shows a plan view of a sheep enclosure.

The enclosure  $ABCDEA$ , as shown in Figure 4, consists of a rectangle  $BCDE$  joined to an equilateral triangle  $BFA$  and a sector  $FEA$  of a circle with radius  $x$  metres and centre  $F$ .

The points  $B$ ,  $F$  and  $E$  lie on a straight line with  $FE = x$  metres and  $10 \leq x \leq 25$ .

- (a) Find, in  $\text{m}^2$ , the exact area of the sector  $FEA$ , giving your answer in terms of  $x$ , in its simplest form. (2)

Given that  $BC = y$  metres, where  $y > 0$ , and the area of the enclosure is  $1000 \text{ m}^2$ ,

(b) show that

$$y = \frac{500}{x} - \frac{x}{24}(4\pi + 3\sqrt{3}). \quad (3)$$

(c) Hence show that the perimeter  $P$  metres of the enclosure is given by

$$P = \frac{1000}{x} + \frac{x}{12}(4\pi + 36 - 3\sqrt{3}). \quad (3)$$

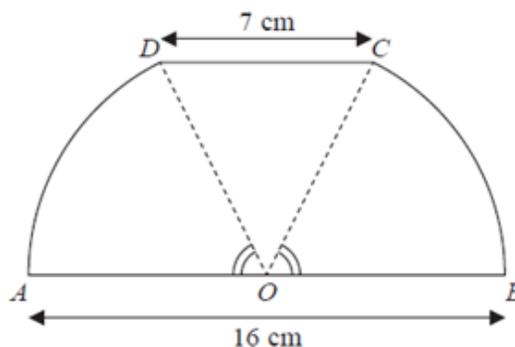
(d) Use calculus to find the minimum value of  $P$ , giving your answer to the nearest metre. (5)

(e) Justify, by further differentiation, that the value of  $P$  you have found is a minimum. (2)

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**Figure 1**

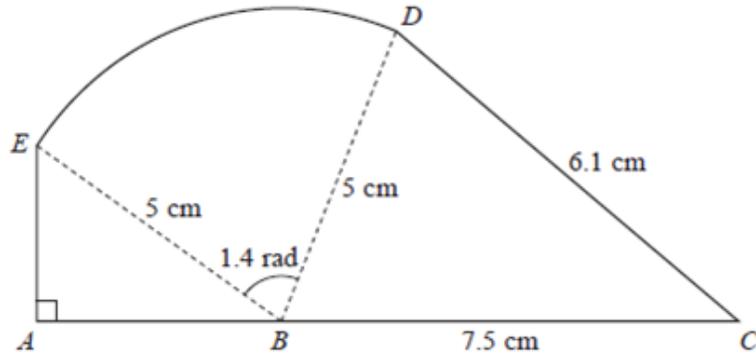
Figure 1 shows a sketch of a design for a scraper blade. The blade  $AOBCDA$  consists of an isosceles triangle  $COD$  joined along its equal sides to sectors  $OBC$  and  $ODA$  of a circle with centre  $O$  and radius  $8 \text{ cm}$ . Angles  $AOD$  and  $BOC$  are equal.  $AOB$  is a straight line and is parallel to the line  $DC$ .  $DC$  has length  $7 \text{ cm}$ .

(a) Show that the angle  $COD$  is  $0.906$  radians, correct to 3 significant figures. (2)

(b) Find the perimeter of  $AOBCDA$ , giving your answer to 3 significant figures. (3)

(c) Find the area of  $AOBCDA$ , giving your answer to 3 significant figures. (3)

6.  
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**Figure 2**

The shape  $ABCDEA$ , as shown in Figure 2, consists of a right-angled triangle  $EAB$  and a triangle  $DBC$  joined to a sector  $BDE$  of a circle with radius 5 cm and centre  $B$ .

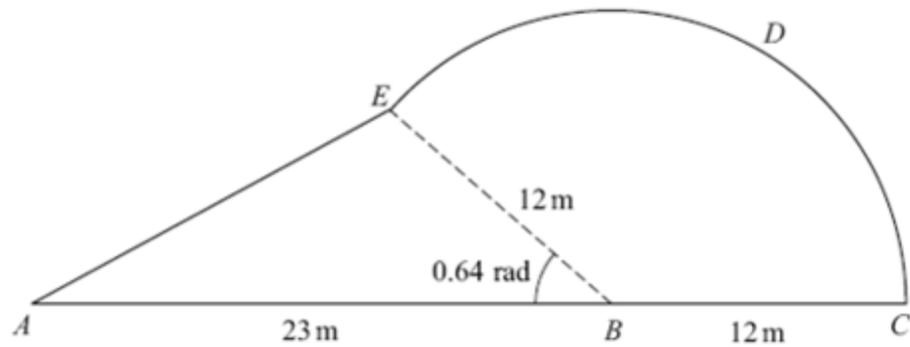
The points  $A$ ,  $B$  and  $C$  lie on a straight line with  $BC = 7.5$  cm.

Angle  $EAB = \frac{\pi}{2}$  radians, angle  $EBD = 1.4$  radians and  $CD = 6.1$  cm.

- (a) Find, in  $\text{cm}^2$ , the area of the sector  $BDE$ . (2)
- (b) Find the size of the angle  $DBC$ , giving your answer in radians to 3 decimal places. (2)
- (c) Find, in  $\text{cm}^2$ , the area of the shape  $ABCDEA$ , giving your answer to 3 significant figures. (5)

- 7.

5.



**Figure 2**

Figure 2 shows a plan view of a garden.

The plan of the garden  $ABCDEA$  consists of a triangle  $ABE$  joined to a sector  $BCDE$  of a circle with radius  $12\text{ m}$  and centre  $B$ .

The points  $A$ ,  $B$  and  $C$  lie on a straight line with  $AB = 23\text{ m}$  and  $BC = 12\text{ m}$ .

Given that the size of angle  $ABE$  is exactly  $0.64$  radians, find

(a) the area of the garden, giving your answer in  $\text{m}^2$ , to 1 decimal place,

(4)

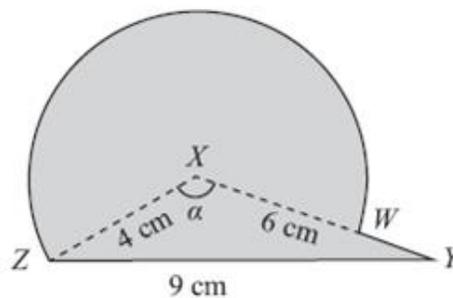
(b) the perimeter of the garden, giving your answer in metres, to 1 decimal place.

(5)

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**Figure 2**

The triangle  $XYZ$  in Figure 1 has  $XY = 6\text{ cm}$ ,  $YZ = 9\text{ cm}$ ,  $ZX = 4\text{ cm}$  and angle  $ZXY = \alpha$ . The point  $W$  lies on the line  $XY$ .

The circular arc  $ZW$ , in Figure 1 is a major arc of the circle with centre  $X$  and radius 4 cm.

(a) Show that, to 3 significant figures,  $\alpha = 2.22$  radians. (2)

(b) Find the area, in  $\text{cm}^2$ , of the major sector  $XZWX$ . (3)

The region enclosed by the major arc  $ZW$  of the circle and the lines  $WY$  and  $YZ$  is shown shaded in Figure 1.

Calculate

(c) the area of this shaded region, (3)

(d) the perimeter  $ZWYZ$  of this shaded region. (4)

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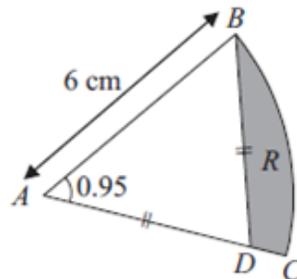


Figure 2

Figure 2 shows  $ABC$ , a sector of a circle of radius 6 cm with centre  $A$ . Given that the size of angle  $BAC$  is 0.95 radians, find

(a) the length of the arc  $BC$ , (2)

(b) the area of the sector  $ABC$ . (2)

The point  $D$  lies on the line  $AC$  and is such that  $AD = BD$ . The region  $R$ , shown shaded in Figure 2, is bounded by the lines  $CD$ ,  $DB$  and the arc  $BC$ .

(c) Show that the length of  $AD$  is 5.16 cm to 3 significant figures. (2)

Find

(d) the perimeter of  $R$ , (2)

(e) the area of  $R$ , giving your answer to 2 significant figures. (4)

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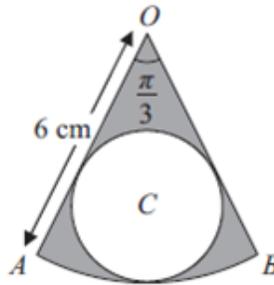


Figure 1

The shape shown in Figure 1 is a pattern for a pendant. It consists of a sector  $OAB$  of a circle centre  $O$ , of radius 6 cm, and angle  $AOB = \frac{\pi}{3}$ . The circle  $C$ , inside the sector, touches the two straight edges,  $OA$  and  $OB$ , and the arc  $AB$  as shown.

Find

(a) the area of the sector  $OAB$ , (2)

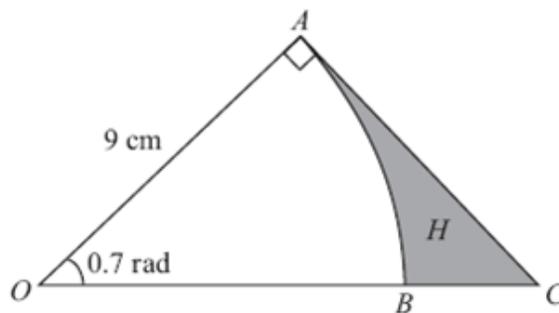
(b) the radius of the circle  $C$ . (3)

The region outside the circle  $C$  and inside the sector  $OAB$  is shown shaded in Figure 1.

(c) Find the area of the shaded region. (2)

11.

6.



**Figure 1**

Figure 1 shows the sector  $OAB$  of a circle with centre  $O$ , radius 9 cm and angle 0.7 radians.

(a) Find the length of the arc  $AB$ .

(2)

(b) Find the area of the sector  $OAB$ .

(2)

The line  $AC$  shown in Figure 1 is perpendicular to  $OA$ , and  $OBC$  is a straight line.

(c) Find the length of  $AC$ , giving your answer to 2 decimal places.

(2)

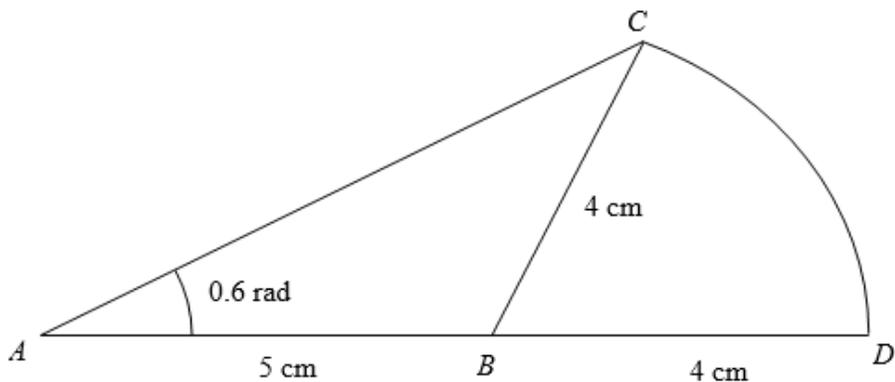
The region  $H$  is bounded by the arc  $AB$  and the lines  $AC$  and  $CB$ .

(d) Find the area of  $H$ , giving your answer to 2 decimal places.

(3)

12.

4.



**Figure 1**

An emblem, as shown in Figure 1, consists of a triangle  $ABC$  joined to a sector  $CBD$  of a circle with radius 4 cm and centre  $B$ . The points  $A$ ,  $B$  and  $D$  lie on a straight line with  $AB = 5$  cm and  $BD = 4$  cm. Angle  $BAC = 0.6$  radians and  $AC$  is the longest side of the triangle  $ABC$ .

(a) Show that angle  $ABC = 1.76$  radians, correct to three significant figures.

(4)

(b) Find the area of the emblem.

(3)