14 Calculate the circumference of a circle with radius 4.7 cm.

$$C = 2\pi r$$
$$= 2 \times \pi \times 4.7 =$$
$$= 29.5 \text{ cm}$$
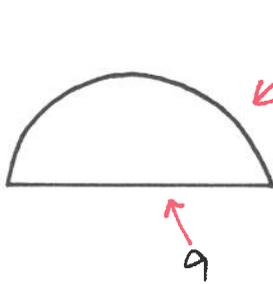
.............29.5............. cm [2]

8

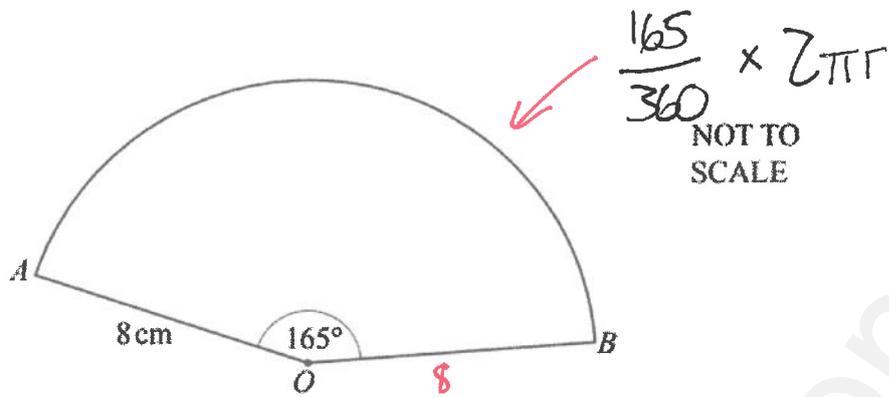NOT TO
SCALE

─── 9 cm ───
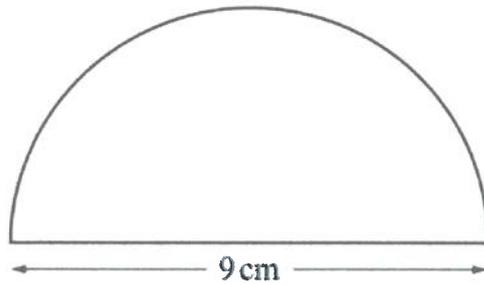
The diagram shows a semicircle with diameter 9 cm.

Calculate the total perimeter of this semicircle.
Give your answer in exact form.

$$\frac{\pi \times d}{2} = \frac{\pi \times 9}{2}$$
$$= \frac{9\pi}{2}$$

Perimeter = $\frac{9\pi}{2} + 9$

$\frac{9\pi}{2} + 9$ .... cm [3]

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9

$$\frac{165}{360} \times 2\pi r$$

NOT TO SCALE

A

8 cm   165°

O   8   B
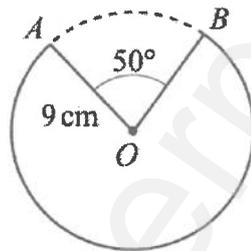
The diagram shows a sector of a circle with centre O, radius 8 cm and sector angle 165°.

(a) Calculate the total perimeter of the sector.

$$\text{Perimeter} = \frac{165}{360} \times 2 \times \pi \times 8 + 8 + 8$$

$$= \frac{11}{24} \times 16\pi + 16$$

$$= \frac{22}{3}\pi + 16 \qquad = 39.0 \text{ cm}$$

.... 39.0 .... cm [3]
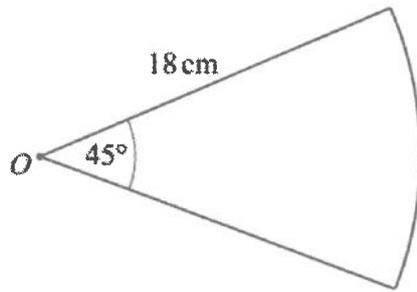
(e)

A ⌣ B

50°

9 cm

O

NOT TO SCALE

The diagram shows a circle of radius 9 cm, centre O.
The minor sector AOB, with sector angle 50°, is removed from the circle.

Calculate the length of the major arc AB.

angle: $360 - 50 = 310°$

$$\text{length:} \frac{310}{360} \times 2 \times \pi \times 9$$

$$= \frac{31}{36} \times 18\pi$$

$$= \frac{31}{2}\pi \qquad = 48.7 \text{ cm}$$

.... 48.7 .... cm [3]
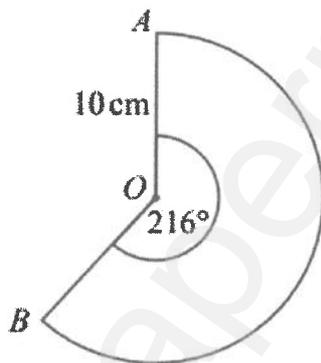
www.pastpaperpenguin.com

10

18 cm

45°

O

NOT TO
SCALE

The diagram shows a sector of a circle, centre O.
The length of the arc is $n\pi$ cm .

Find the value of n.

$$l = \frac{45}{360} \times 2 \times \pi \times 18$$

$$= \frac{1}{8} \times 36\pi$$

$$= \frac{9}{2}\pi$$

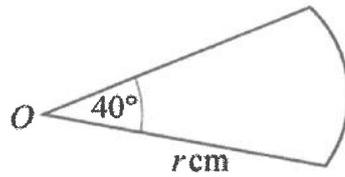$$n = \underline{\qquad \frac{9}{2} \qquad} \quad [2]$$

(b)

A

10 cm

O

216°

B

NOT TO
SCALE

AOB is a sector of a circle, centre O.
$AO = 10$ cm and the sector angle is $216°$.

(i) Calculate the length of the arc of this sector.
Give your answer as a multiple of π.

$$l = \frac{216}{360} \times 2\pi r$$

$$= \frac{3}{5} \times 2 \times \pi \times 10$$

$$= \frac{3}{5} \times 20\pi$$

$$= 12\pi$$

$$\underline{\qquad 12\pi \qquad} cm \quad [2]$$

9

NOT TO SCALE

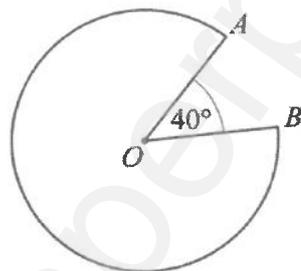The diagram shows an arc of a circle, centre O, radius r cm.
The length of the arc is $k\pi r$ cm.

Find the value of k.
Give your answer as a fraction in its simplest form.

$$L = \frac{40}{360} \times 2\pi r$$

$$= \frac{1}{9} \times 2\pi r$$

$$= \frac{2}{9}\pi r$$

$k = $ .... $\frac{2}{9}$ .... [2]

20

NOT TO SCALE

The diagram shows a sector of a circle, centre O.
The radius of the circle is 6 cm.

Calculate the length of the major arc AB.
Give your answer in its simplest form in terms of π.

angle: $360 - 40 = 320°$ $\qquad = \frac{8}{9} \times 12\pi$

$$L = \frac{320}{360} \times 2\pi r \qquad = \frac{32}{3}\pi$$

$$= \frac{8}{9} \times 2 \times \pi \times 6$$

.... $\frac{32}{3}\pi$ ....cm [3]

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12 The total perimeter of a semicircle is 19.02 cm.

Calculate the radius of the semicircle.

$\dfrac{2\pi r}{2} = \pi r$

$2r$
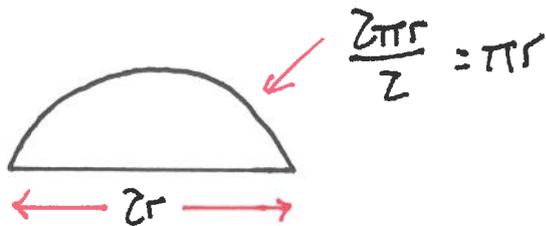
$\text{Perimeter} = 2r + \pi r$

$19.02 = r(2 + \pi)$

$\div(2+\pi) \qquad \div(2+\pi)$

$r = \dfrac{19.02}{2+\pi}$

$= 3.70 \text{ cm}$

.... 3.70 .... cm [3]

15 The perimeter of a sector of a circle with radius 8 cm is 26 cm.

Calculate the angle of this sector.

8 cm

x

8 cm
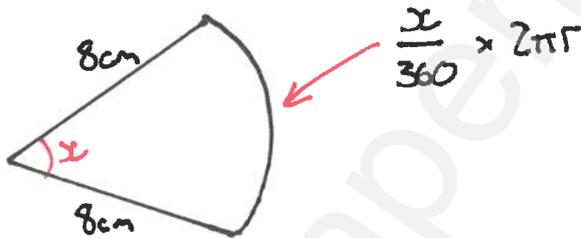
$\dfrac{x}{360} \times 2\pi r$

$\text{Perimeter} = 8 + 8 + \dfrac{x}{360} \times 2 \times \pi \times 8$

$26 = 16 + \dfrac{x}{360} \times 16\pi$

$26 = 16 + \dfrac{16\pi x}{360}$

$-16 \qquad\qquad -16$

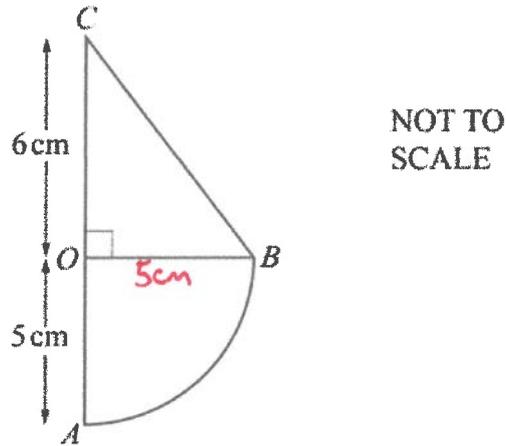$10 = \dfrac{16\pi x}{360}$

$10 = \dfrac{2\pi x}{45}$

$\times 45 \qquad\qquad \times 45$

$450 = 2\pi x$

$\div 2\pi \qquad\qquad \div 2\pi$

$x = 71.6°$

.... [3]

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NOT TO SCALE

The diagram shows a shape made from a quarter-circle, OAB, and a right-angled triangle OBC.
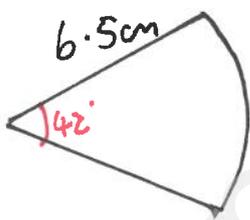The radius of the circle is 5 cm and $OC = 6$ cm.

Calculate the area of the shape.

Triangle: Area $= \frac{1}{2} \times b \times h$

$= \frac{1}{2} \times 5 \times 6$

$= 15 \text{cm}^2$

Quarter-Circle: Area $= \frac{\pi r^2}{4}$

$= \frac{\pi \times 5^2}{4}$

$= 19.6 \text{cm}^2$

Total Area: $15 + 19.6 =$ ....34.6........ cm² [3]

9   Calculate the area of the sector of a circle with radius 65 mm and sector angle 42°.
Give your answer in square centimetres.

$r = 6.5 \text{cm}$
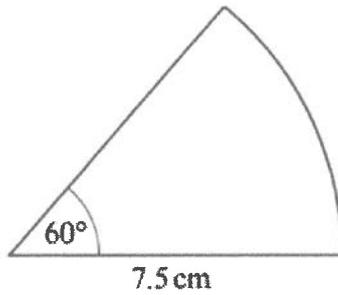

6.5cm

42°

Area $= \frac{42}{360} \times \pi r^2$

$= \frac{7}{60} \times \pi \times 6.5^2$

$= 15.5 \text{cm}^2$

........15.5........ cm² [3]
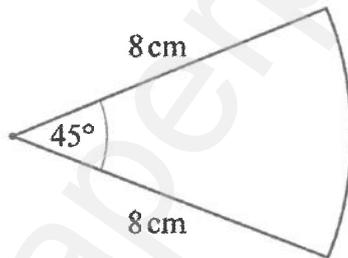
NOT TO SCALE

60°

7.5 cm

Calculate the area of this sector of a circle.

$$\text{Area} = \frac{60}{360} \times \pi r^2$$

$$= \frac{1}{6} \times \pi \times 7.5^2$$

$$= 29.5 \text{ cm}^2$$

.... 29.5 .... cm² [2]

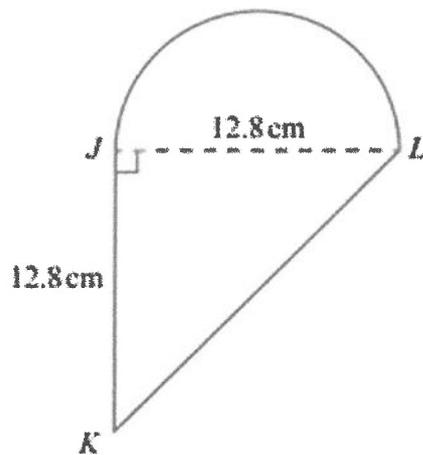**6** Find the area of the sector.
Give your answer, in terms of π, in its simplest form.

8 cm

45°

8 cm

NOT TO SCALE

$$\text{Area} = \frac{45}{360} \times \pi r^2$$

$$= \frac{1}{8} \times \pi \times 8^2$$

$$= \frac{1}{8} \times 64\pi$$

$$= 8\pi \text{ cm}^2$$

.... 8π .... cm² [2]

NOT TO SCALE

The diagram shows a shape made from a triangle *JKL* and a semicircle with diameter *JL*.
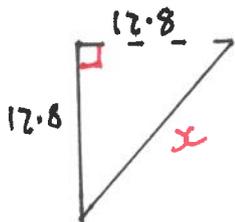*JKL* is an isosceles right-angled triangle with $JK = JL = 12.8$ cm.

(a) Calculate the area of this shape.

Triangle: $A = \frac{1}{2} \times b \times h$

$= \frac{1}{2} \times 12.8 \times 12.8$

$= \underline{81.92 \text{ cm}^2}$

Semi-Circle: $A = \frac{\pi r^2}{2}$

$= \frac{\pi \times 6.4^2}{2}$

$= \underline{64.34 \text{ cm}^2}$

Total: $81.92 + 64.34 = \underline{146.3}$ .... cm² [3]

(b) Calculate the perimeter of this shape.

$12.8^2 + 12.8^2 = x^2$

$163.84 + 163.84 = x^2$

$x^2 = 327.68$

$x = \sqrt{327.68}$

$= \underline{18.1 \text{ cm}}$

$\frac{\pi d}{2} = \frac{\pi \times 12.8}{2}$

$= \underline{20.1 \text{ cm}}$

Perimeter $= 12.8 + 20.1 + 18.1$

$= \underline{51.0 \text{ cm}}$

.... $\underline{51.0}$ .... cm [4]

12

NOT TO
SCALE

6 cm

$x°$
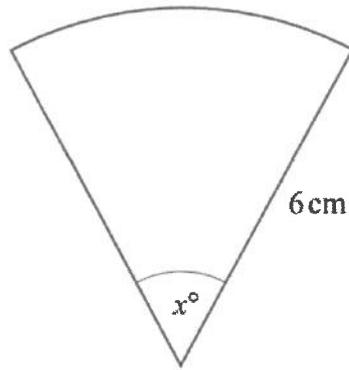
The area of this sector is $5\pi \text{ cm}^2$.

Find the value of x.

$$\text{Area} = \frac{x}{360} \times \pi r^2$$

$$5\pi = \frac{x}{360} \times \pi \times 6^2$$

$$5\pi = \frac{x}{360} \times \pi \times 36$$

$$5\pi = \frac{\pi x}{10}$$
×10   ×10

$$50\pi = \pi x$$
÷π   ÷π

$$\underline{50 = x}$$

$x = $ ....$50°$................. [3]

24

P

8 cm

6.4 cm

NOT TO SCALE

x

Q

The diagram shows a sector of a circle of radius 8 cm.
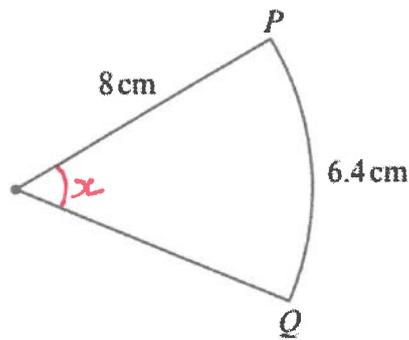The length of the arc PQ is 6.4 cm.

Find the area of the sector.

Arc length: $\quad l = \dfrac{x}{360} \times 2\pi r$

$6.4 = \dfrac{x}{360} \times 2 \times \pi \times 8$

$6.4 = \dfrac{x}{360} \times 16\pi$

$6.4 = \dfrac{2\pi x}{45}$

$\times 45 \qquad \times 45$

$288 = 2\pi x$

$\div 2\pi \qquad \div 2\pi$

$\underline{x = 45.83..}$

STO

Area: $\quad A = \dfrac{x}{360} \times \pi r^2$

$= \dfrac{45.83..}{360} \times \pi \times 8^2$

$= \dfrac{45.83..}{360} \times 64\pi$

$= \underline{25.6 \, cm^2}$

...........25.6........... cm² [4]

19 (a)
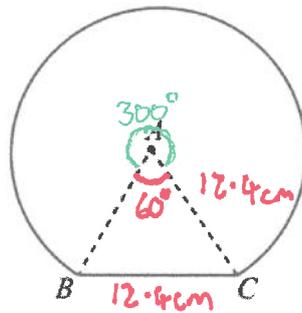
NOT TO SCALE

The diagram shows a shape made from an equilateral triangle *ABC* and a sector of a circle.
Points *B* and *C* lie on the circle, centre *A*.
The side length of the equilateral triangle is 12.4 cm.

Work out the perimeter of the shape.

Length of major arc:

$$L = \frac{300}{360} \times 2\pi r$$
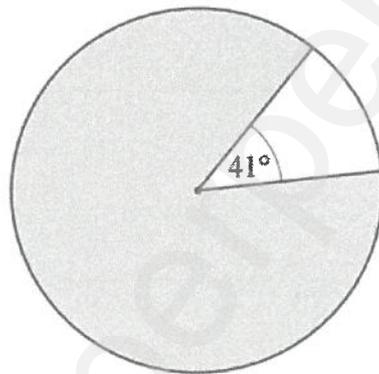
$$= \frac{5}{6} \times 2 \times \pi \times 12.4$$

$$= 64.9 \text{ cm}$$

Perimeter $= 12.4 + 64.9$

$$= 77.3 \text{ cm}$$

.................**77.3**................. cm [3]

(b)

41°

NOT TO SCALE

The diagram shows two sectors of a circle.
The major sector is shaded.
The area of the major sector is 74.5 cm².

Calculate the radius of the circle.

angle: $360 - 41 = 319°$

$$\text{Area} = \frac{319}{360} \times \pi r^2$$

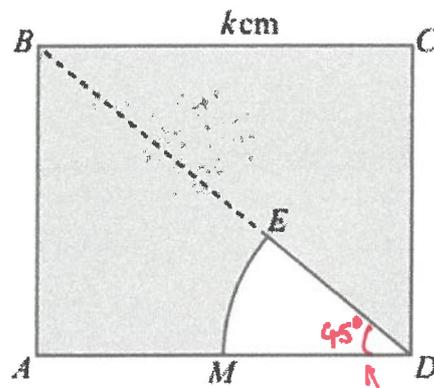$$74.5 = \frac{319}{360} \times \pi \times r^2$$

×360   ×360

$$26820 = 319\pi r^2$$

÷319π   ÷319π

$$\frac{26820}{319\pi} = r^2$$

$$\sqrt{\frac{26820}{319\pi}} = r$$

.................**5.17**................. cm [3]

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k cm

B C

NOT TO
SCALE

E

45°

A M D

Square, so angle = 45°

The diagram shows a square $ABCD$ with side length k cm.
MDE is a sector of a circle, centre D.
E lies on the diagonal, BD, of the square.
M is the midpoint of AD.

Find the percentage of the square that is shaded.

radius: radius = $\frac{1}{2}$ AD

radius = $\frac{k}{2}$

Area of sector:

Area = $\frac{45}{360} \times \pi r^2$

$= \frac{1}{8} \times \pi \times \left(\frac{k}{2}\right)^2$

$= \frac{1}{8} \times \pi \times \frac{k^2}{4}$

$= \frac{\pi k^2}{32}$

Area of square = $k \times k$

$= k^2$

Shaded Area:

$k^2 - \frac{\pi k^2}{32}$

Fraction shaded:

$\dfrac{k^2 - \frac{\pi k^2}{32}}{k^2}$ ← shaded

← total area

divide top and bottom by k^2:

$\dfrac{1 - \frac{\pi}{32}}{1}$
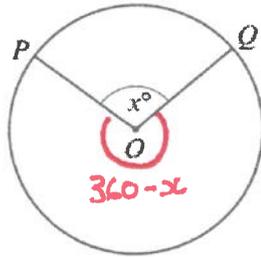
$= 1 - \frac{\pi}{32}$

$= 0.9018$

Convert to percentage:

$0.9018 \times 100 = \underline{90.2\%}$

11 (a)

In the circle, centre O, the length of the minor arc PQ is $\frac{3}{7}$ of the length of the major arc PQ.
Show that $x = 108$.

Minor arc:
$$l_1 = \frac{x}{360} \times 2\pi r$$

Major arc
$$l_2 = \frac{360-x}{360} \times 2\pi r$$

Minor $= \frac{3}{7} \times$ Major:

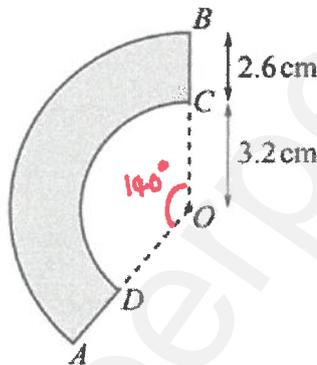$$\frac{x}{360} \times 2\pi r = \frac{3}{7} \times \frac{360-x}{360} \times 2\pi r$$

$\div 2\pi r \qquad \div 2\pi r$

$$\frac{x}{360} = \frac{3}{7} \times \frac{360-x}{360}$$

$\times 360 \qquad \times 360$

$$x = \frac{3}{7}(360-x)$$

$\times 7 \qquad \times 7$

$$7x = 3(360-x)$$

$7x = 1080 - 3x$
$+3x \qquad +3x$
$10x = 1080$
$\div 10 \qquad \div 10$
$\underline{x = 108}$

11

The diagram shows a shape, $ABCD$, formed by the sectors of two circles with the same centre O.
Both sector angles are $140°$, $OC = 3.2\,cm$ and $CB = 2.6\,cm$.
The area of the shape is $k\pi\,cm^2$.

Find the value of k.

Large sector:
$$A = \frac{140}{360} \times \pi r^2$$
$$= \frac{7}{18} \times \pi \times 5.8^2$$
$$= \frac{5887}{450}\pi$$

Small sector:
$$A = \frac{140}{360} \times \pi r^2$$
$$= \frac{7}{18} \times \pi \times 3.2^2$$
$$= \frac{896}{225}\pi$$

Shaded area:
$$\frac{5887}{450}\pi - \frac{896}{225}\pi$$
$$= 9.1\pi$$

$k =$ ....9.1............ [3]

9 **(a)**

M   A   B

11cm

11cm

D   C   N

NOT TO
SCALE
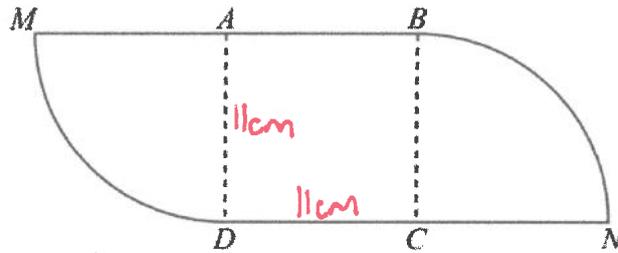
The diagram shows a shape made from a square *ABCD* and two equal sectors of a circle.
The square has side 11 cm.
MAB and *DCN* are straight lines.

(i) Calculate the area of the shape.

Square: $A = 11 \times 11$

$= 121 \text{ cm}^2$

Quarter - circle:

$A = \dfrac{\pi r^2}{4}$

$= \dfrac{\pi \times 11^2}{4} = \dfrac{121\pi}{4}$

Total: $121 + \dfrac{121\pi}{4} + \dfrac{121\pi}{4}$

$= 121 + \dfrac{121\pi}{2}$

$= 311$

_____311_____ cm² [3]

(ii) Calculate the perimeter of the shape.

Arc length of quarter circle:

$l = \dfrac{1}{4} \times 2\pi r$

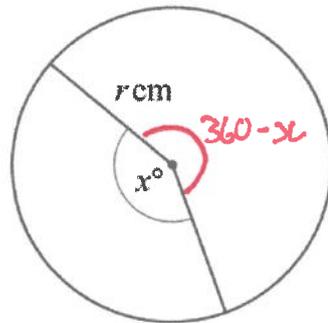$= \dfrac{1}{4} \times 2 \times \pi \times 11$

$= \dfrac{11}{2}\pi$

Perimeter:

$11 + 11 + 11 + 11 + \dfrac{11}{2}\pi + \dfrac{11}{2}\pi$

$= 44 + 11\pi$

$= 78.6 \text{ cm}$

_____78.6_____ cm [3]

(c)

NOT TO
SCALE

The diagram shows a circle, radius r cm and minor sector angle $x°$.
The **perimeter** of the major sector is three times the **perimeter** of the minor sector.

Show that $x = \dfrac{90(\pi - 2)}{\pi}$.

Perimeter of major sector:

arc length $= \dfrac{360 - x}{360} \times 2\pi r$

perimeter $= \dfrac{360 - x}{360} \times 2\pi r + 2r$

Perimeter of minor sector:

arc length $= \dfrac{x}{360} \times 2\pi r$

perimeter $= \dfrac{x}{360} \times 2\pi r + 2r$

Perimeter of major sector $= 3 \times$ Perimeter of minor sector:

$$\dfrac{360 - x}{360} \times 2\pi r + 2r = 3\left(\dfrac{x}{360} \times 2\pi r + 2r\right)$$

$$\dfrac{360 - x}{360} \times 2\pi r + 2r = \dfrac{3x}{360} \times 2\pi r + 6r$$
$$\qquad\qquad\qquad -2r \qquad\qquad\qquad\qquad -2r$$

$$\dfrac{360 - x}{360} \times 2\pi r = \dfrac{3x}{360} \times 2\pi r + 4r$$
$$\qquad\quad \times 360 \qquad\qquad \times 360 \qquad\quad \times 360$$

[4]

$$(360 - x) \times 2\pi r = 3x \times 2\pi r + 1440r$$
$$\div r \qquad\qquad\qquad \div r \qquad\qquad \div r$$

$$2\pi(360 - x) = 3x \times 2\pi + 1440$$

$$720\pi - 2\pi x = 6\pi x + 1440$$
$$\quad + 2\pi x \qquad\quad + 2\pi x$$

(c) continued:

$$720\pi - 2\pi x = 6\pi x + 1440$$
$$+ 2\pi x \qquad + 2\pi x$$

$$720\pi = 8\pi x + 1440$$
$$-1440 \qquad -1440$$

$$720\pi - 1440 = 8\pi x$$
$$\div 8 \qquad \div 8$$

$$90\pi - 180 = \pi x$$
$$\div \pi \qquad \div \pi$$

$$x = \frac{90\pi - 180}{\pi}$$

$$x = \frac{90(\pi - 2)}{\pi}$$