

1. Given that  $f(x) = 5x^3$ , evaluate  $f(-2)$ .

2

$$\begin{aligned} f(-2) &= 5(-2)^3 \checkmark \\ &= 5(-8) \\ &= \underline{\underline{-40}} \checkmark \end{aligned}$$

2. Evaluate  $\frac{3}{8} \times 1\frac{5}{7}$ .

Give your answer in its simplest form.

2

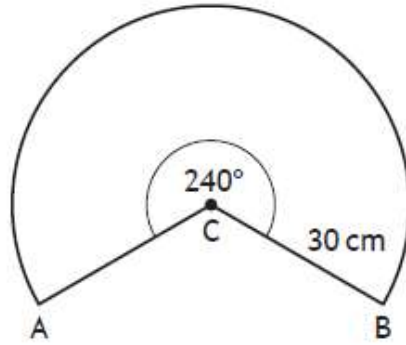
$$\frac{3}{8} \times \frac{12}{7} \checkmark = \frac{36}{56} = \frac{18}{28} = \underline{\underline{\frac{9}{14}}} \checkmark$$

3. Expand and simplify  $(x+5)(2x^2-7x-3)$ .

3

$$\begin{aligned} &x(2x^2-7x-3) + 5(2x^2-7x-3) \\ &= \underline{2x^3 - 7x^2 - 3x} \checkmark + \underline{10x^2 - 35x - 15} \checkmark \\ &= 2x^3 + 3x^2 - 38x - 15 \checkmark \end{aligned}$$

4. The diagram below shows a sector of a circle, centre C.



The radius of the circle is 30 centimetres.

Calculate the length of the major arc AB.

Take  $\pi = 3.14$ .

3

$$\frac{\text{Arc}}{\pi D} = \frac{240}{360} \quad \checkmark$$

$$\frac{\text{Arc}}{3.14(60)} = \frac{2}{3}$$

$$\text{Arc} = \frac{2}{3} \times 3.14 \times 60 \quad \checkmark$$

$$\text{Arc} = 3.14 \times 40$$

$$\text{Arc} = 31.4 \times 4$$

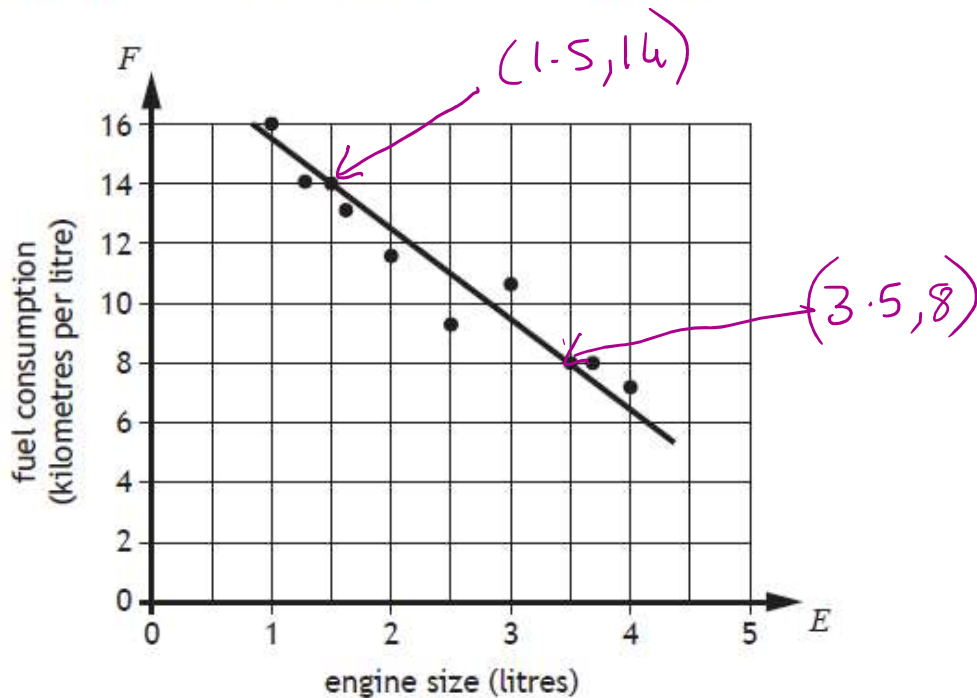
$$\text{Arc} = 125.6 \text{ cm} \quad \checkmark$$

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6. The fuel consumption of a group of cars is recorded.

The scattergraph shows the relationship between the fuel consumption,  $F$  kilometres per litre, and the engine size,  $E$  litres, of the cars.



A line of best fit has been drawn.

- (a) Find the equation of the line of best fit in terms of  $F$  and  $E$ .

Give the equation in its simplest form.

3

$$\begin{aligned}
 m &= \frac{14 - 8}{1.5 - 3.5} \\
 &= \frac{6}{-2} \\
 &= \underline{\underline{-3}}
 \end{aligned}$$

$$\begin{aligned}
 y - b &= m(x - a) \\
 y - 14 &= -3(x - 1.5) \\
 y - 14 &= -3x + 4.5 \\
 y &= -3x + 18.5 \\
 \therefore \underline{\underline{F = -3E + 18.5}}
 \end{aligned}$$

6. (continued)

Amaar's car has an engine size of 1.1 litres.

- (b) Use your equation from part (a) to estimate how many kilometres per litre he should expect to get.

1

$$\begin{aligned}
 F &= -3(1.1) + 18.5 \\
 &= -3.3 + 18.5 = 15.2 \text{ km/litre}
 \end{aligned}$$

7. The area of a trapezium is given by the formula

$$A = \frac{1}{2}h(x+y).$$

Make  $x$  the subject of the formula.

3

$$\frac{1}{2}h(x+y) = A$$

$$h(x+y) = 2A \quad \checkmark$$

$$x+y = \frac{2A}{h} \quad \checkmark$$

$$\underline{\underline{x = \frac{2A}{h} - y}} \quad \checkmark$$

8. John bought 7 bags of cement and 3 bags of gravel.

The total weight of these bags was 215 kilograms.

(a) Write down an equation to illustrate this information.

1

$$7C + 3G = 215 \quad \checkmark$$

Shona bought 5 bags of cement and 4 bags of gravel.

The total weight of her bags was 200 kilograms.

(b) Write down an equation to illustrate this information.

1

$$5C + 4G = 200 \quad \checkmark$$

(c) Calculate the weight of one bag of cement and the weight of one bag of gravel.

4

$$7C + 3G = 215 \quad \textcircled{1} \quad \checkmark$$

$$5C + 4G = 200 \quad \textcircled{2}$$

$$\textcircled{1} \times 4 \quad 28C + 12G = 860 \quad \textcircled{3}$$

$$\textcircled{2} \times 3 \quad 15C + 12G = 600 \quad \textcircled{4}$$

$$\textcircled{3} - \textcircled{4} \quad 13C = 260$$

$$\underline{\underline{C = 20}} \quad \checkmark$$

Sub 20 for C in  $\textcircled{1}$

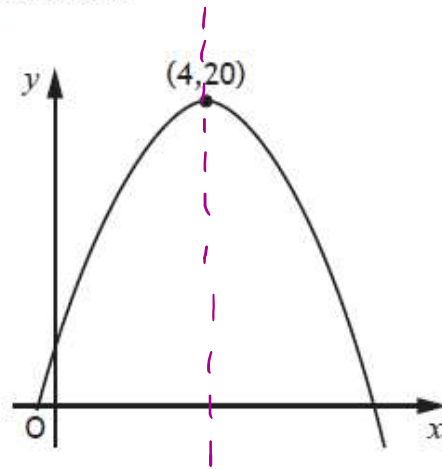
$$140 + 3G = 215$$

$$3G = 75 \quad \checkmark$$

$$\underline{\underline{G = 25}} \quad \checkmark$$

$\therefore$  Cement = 20kg  $\checkmark$   
Gravel = 25kg  $\checkmark$   
IN CONTEXT

9. The graph shows a parabola.



The maximum turning point has coordinates (4,20) as shown in the diagram.

(a) Write down the equation of the axis of symmetry of the graph.

1

$$TP = (4, 20) \rightarrow \underline{x = 4} \checkmark$$

The equation of the parabola is of the form  $y = b - (x + a)^2$ .

(b) State the values of

(i)  $a$

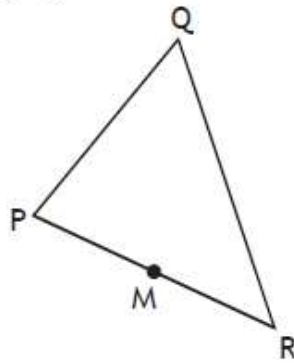
1

(ii)  $b$ .

$$y = -(x - 4)^2 + 20 \quad \text{so} \quad \begin{aligned} a &= -4 \checkmark^2 \\ b &= 20 \checkmark^3 \end{aligned}$$

1

10. In triangle PQR,  $\vec{PR} = \begin{pmatrix} 6 \\ -4 \end{pmatrix}$  and  $\vec{RQ} = \begin{pmatrix} -1 \\ 8 \end{pmatrix}$ .



- (a) Express  $\vec{PQ}$  in component form.

$$\vec{PQ} = \vec{PR} + \vec{RQ} = \begin{pmatrix} 6 \\ -4 \end{pmatrix} + \begin{pmatrix} -1 \\ 8 \end{pmatrix} = \underline{\underline{\begin{pmatrix} 5 \\ 4 \end{pmatrix}}}$$

M is the midpoint of PR.

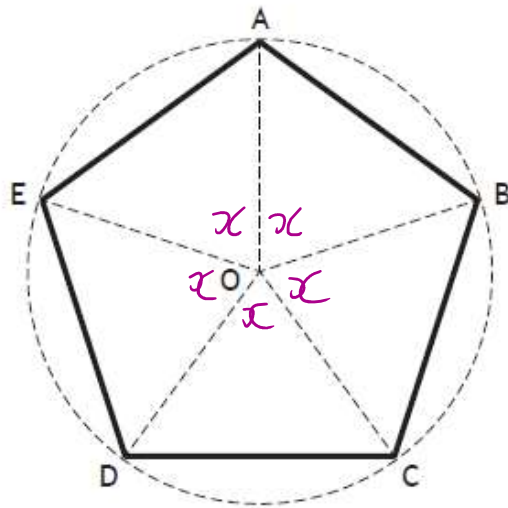
- (b) Express  $\vec{MQ}$  in component form.

$$\begin{aligned} \vec{MQ} &= \vec{MR} + \vec{RQ} = \frac{1}{2}\vec{PR} + \vec{RQ} \\ &= \begin{pmatrix} 3 \\ -2 \end{pmatrix} + \begin{pmatrix} -1 \\ 8 \end{pmatrix} \\ &= \underline{\underline{\begin{pmatrix} 2 \\ 6 \end{pmatrix}}} \end{aligned}$$

11. Pam is designing a company logo.

She starts by drawing a regular pentagon ABCDE.

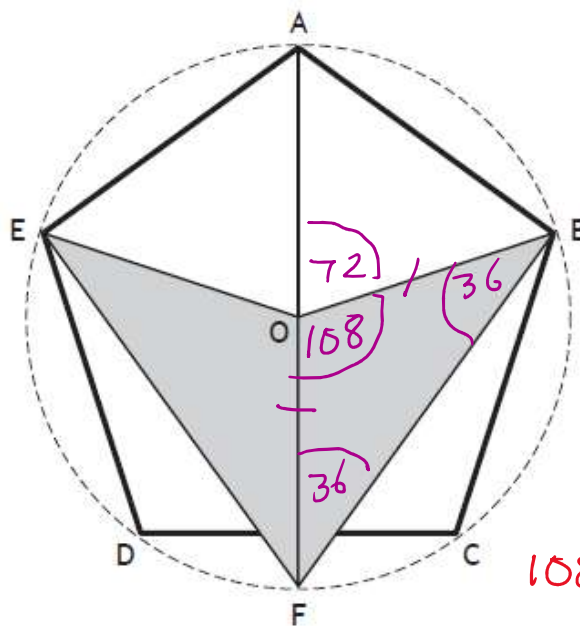
The vertices of the pentagon lie on the circumference of a circle with centre O.



$$5x = 360^\circ$$

$$\underline{x = 72^\circ} \quad \checkmark$$

She then adds to the design as shown in the diagram below.



Triangle OFB  
is ISOSCELES.

$$\therefore \underline{\underline{\angle OFB = 36^\circ}}$$

$$108^\circ \checkmark$$

$$36^\circ \checkmark$$

AF is a diameter of the circle.

Calculate the size of angle OFB.

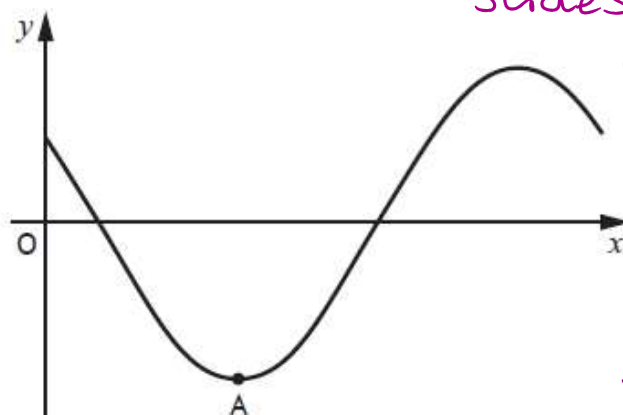


12. Express  $\frac{\sqrt{2}}{\sqrt{40}}$  as a fraction with a rational denominator.

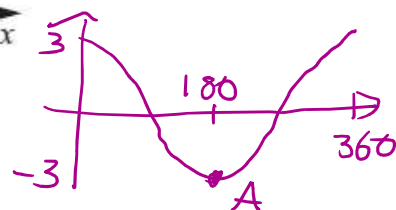
Give your answer in its simplest form.

$$\frac{\sqrt{2}}{\sqrt{40}} \times \frac{\sqrt{40}}{\sqrt{40}} = \frac{\sqrt{80}}{40} = \frac{\sqrt{16} \sqrt{5}}{40} = \frac{4\sqrt{5}}{40} = \frac{\sqrt{5}}{10}$$

13. Part of the graph of  $y = 3 \cos(x + 45)^\circ$  is shown in the diagram.



slides the graph  $45^\circ$  to the left.



The graph has a minimum turning point at A.  
State the coordinates of A.

On  $y = 3 \cos x$   
A is  $(180, -3)$

Since it has moved  $45^\circ$  LEFT,

$$\underline{A = (135^\circ, -3)}$$

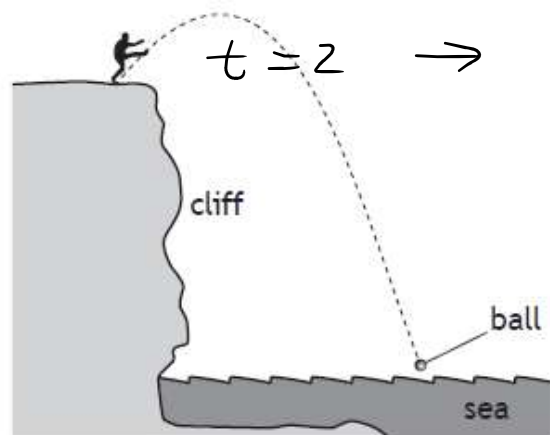
$135^\circ$  ✓  
 $-3$  ✓

14. Solve the equation  $\frac{x}{2} - 1 = \frac{3-x}{5}$ .

3

$$\begin{aligned} \frac{x}{2} - 1 &= \frac{3-x}{5} \\ \frac{x}{2} - \frac{2}{2} &= \frac{3-x}{5} \\ \frac{x-2}{2} &= \frac{3-x}{5} \\ 5(x-2) &= 2(3-x) \\ 5x-10 &= 6-2x \\ 7x &= 16 \\ x &= \frac{16}{7} \end{aligned}$$

15. A ball is kicked from a cliff top.



$$\begin{aligned}
 t = 2 &\rightarrow h = 12(2) - 5(2)^2 \\
 &= 24 - 5(4) \\
 &= 24 - 20 \\
 &= \underline{4\text{ m}} \quad \checkmark
 \end{aligned}$$

The height,  $h$  metres, of the ball relative to the cliff top after  $t$  seconds is given by  $h = 12t - 5t^2$ .

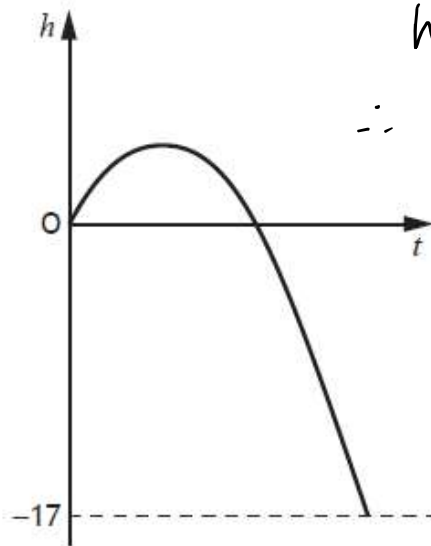
(a) Calculate the height of the ball above the cliff top after 2 seconds.

1

15. (continued)

The graph below represents the height,  $h$  metres, of the ball relative to the cliff top after  $t$  seconds.

$$\begin{array}{r}
 85 \\
 \hline
 1 \ 85 \\
 5 \ 17
 \end{array}$$



$$\begin{aligned}
 h &= -17 \\
 \therefore -17 &= 12t - 5t^2 \quad \checkmark \\
 5t^2 - 12t - 17 &= 0 \quad \checkmark \\
 5t^2 - 17t + 5t - 17 &= 0 \\
 t(5t - 17) + 1(5t - 17) &= 0 \\
 (5t - 17)(t + 1) &= 0 \quad \checkmark \\
 5t - 17 = 0 &\quad t + 1 = 0 \\
 5t &= 17 &\quad t &= -1 \\
 t &= \frac{17}{5} && \quad \checkmark
 \end{aligned}$$

The sea is 17 metres below the cliff top.

(b) After how many seconds will the ball hit the sea?

$$\therefore t = \frac{17}{5} \text{ seconds} \quad \checkmark$$

## Paper 2

1. A charity distributed 80 000 emergency packages during 2018.

This number is expected to increase by 15% each year.

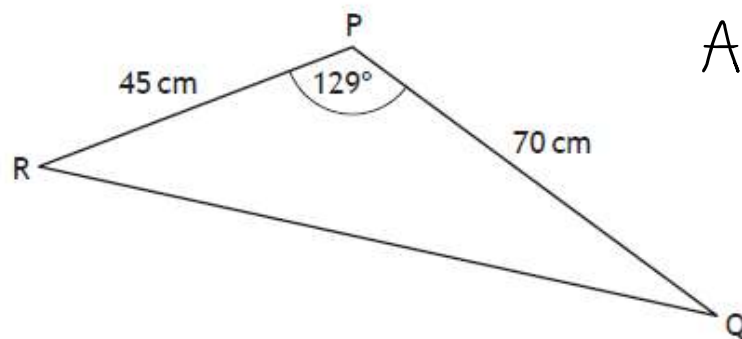
Calculate how many emergency packages the charity expects to distribute in 2021.

$$\begin{aligned} +15\% &\rightarrow 115\% \\ &= 1.15 \end{aligned} \quad \therefore 80000 \times 1.15^3 = \underline{121670 \text{ packages}}$$

2. Find  $|\mathbf{p}|$ , the magnitude of vector  $\mathbf{p} = \begin{pmatrix} 6 \\ 27 \\ -18 \end{pmatrix}$ .

$$\begin{aligned} |\mathbf{p}| &= \sqrt{6^2 + 27^2 + (-18)^2} \\ &= \sqrt{1089} \\ &= \underline{33} \end{aligned}$$

3. The diagram shows triangle PQR.



$$\begin{aligned} A &= \frac{1}{2} qr \sin P \\ &= \frac{1}{2} (45)(70) \sin 129 \\ &= \underline{1224 \text{ cm}^2} \end{aligned}$$

- PR = 45 centimetres
- PQ = 70 centimetres
- Angle QPR = 129°

Calculate the area of triangle PQR.

2

4. A sesame seed weighs  $3.6 \times 10^{-6}$  kilograms.

The weight of a poppy seed is 8% of the weight of a sesame seed.

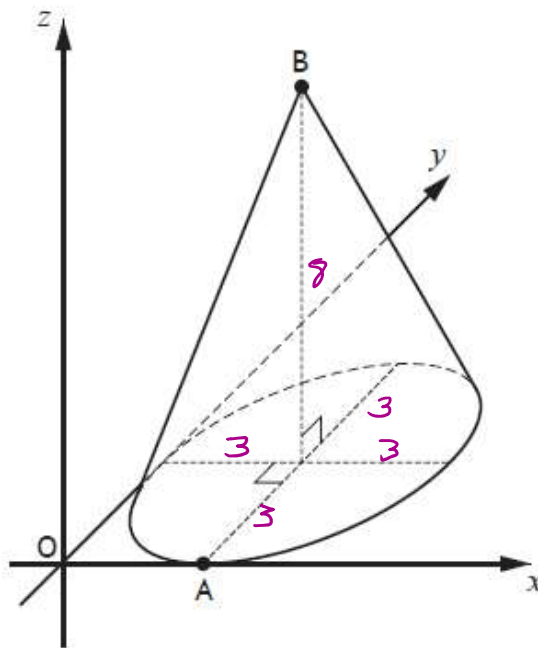
Calculate the weight of a poppy seed in kilograms.

Give your answer in scientific notation.

2

$$\begin{aligned} 8\% \text{ of } 3.6 \times 10^{-6} &= 3.6 \times 10^{-6} \div 100 \times 8 \\ &= 2.88 \times 10^{-7} \text{ kg} \end{aligned}$$

5. The diagram shows a cone with diameter 6 units and height 8 units.



$$\begin{aligned} A &= (3, 0, 0) \\ B &= (3, 3, 8) \end{aligned}$$

- The  $x$ -axis and the  $y$ -axis are tangents to the base
- A is the point of contact between the base and the  $x$ -axis
- B is directly above the centre of the base

Write down the coordinates of A and B.

2

6. Solve the equation  $3x^2 + 9x - 2 = 0$ .

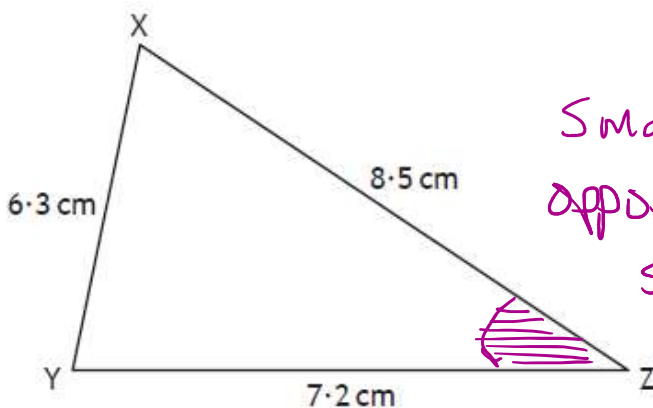
Give your answers correct to 1 decimal place.

3

$$\begin{aligned} a &= 3 \\ b &= 9 \\ c &= -2 \end{aligned}$$

$$\begin{aligned} x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \\ &= \frac{-9 \pm \sqrt{9^2 - 4(3)(-2)}}{2(3)} \quad \checkmark \\ &= \frac{-9 + \sqrt{105}}{6} \quad \text{OR} \quad \frac{-9 - \sqrt{105}}{6} \quad \text{105 } \checkmark \\ &= 0.207 \dots \quad \text{OR} \quad -3.207 \dots \\ &= \underline{0.2} \quad \text{OR} \quad \underline{-3.2} \quad \checkmark \end{aligned}$$

7. Triangle XYZ is shown below.



Smallest angle is opposite smallest side  $\therefore$  find Z

Calculate the size of the smallest angle in triangle XYZ.

3

$$\begin{aligned} \cos Z &= \frac{x^2 + y^2 - z^2}{2xy} \\ &= \frac{7.2^2 + 8.5^2 - 6.3^2}{2(7.2)(8.5)} \quad \checkmark \\ &= \frac{86.4}{122.4} \quad \checkmark \\ \therefore Z &= \cos^{-1}\left(\frac{86.4}{122.4}\right) \\ &= \underline{46.4^\circ} \quad \checkmark \end{aligned}$$

8. A traffic bollard is in the shape of a cylinder with a hemisphere on top.

The bollard has

- diameter 24 centimetres
- height 70 centimetres.

HEMISPHERE

$$V = \frac{2}{3} \pi r^3$$

$$= \frac{2}{3} \pi (12)^3$$

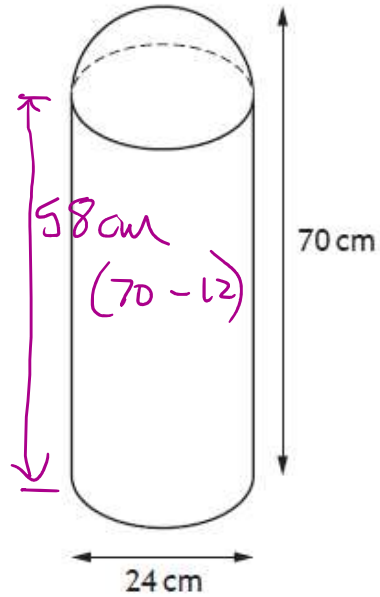
$$= 3619.114737\dots$$

CYLINDER

$$V = \pi r^2 h$$

$$= \pi (12)^2 (58)$$

$$= 26238.58184\dots$$



Calculate the volume of the bollard.

Give your answer correct to 3 significant figures.

5

$$\text{TOTAL} = 26238.58184 + 3619.114737$$

$$= 29857.69658$$

$$= 29900 \text{ cm}^3 \text{ (to 3 sf)}$$

9. Georgie had her roof repaired.

She was charged an extra 2.5% for late payment.

She had to pay a total of £977.85.

Calculate how much she would have saved if she had paid on time.

3

%	£
102.5	977.85
1	9.54
100	954

$$£977.85 - £954$$

$$= \underline{\underline{£23.85}}$$

10. Express  $x^2 + 10x - 15$  in the form  $(x+p)^2 + q$ .

2

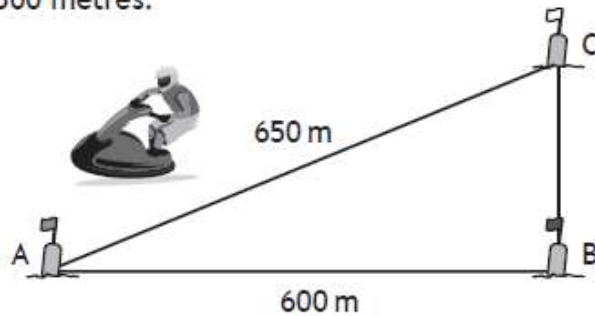
$$\begin{aligned} & (x+5)^2 - 15 - 25 && (x+5)^2 \quad \checkmark \\ = & \underline{\underline{(x+5)^2 - 40}} && -40 \quad \checkmark \end{aligned}$$

11. The diagram shows the course for a jet-ski race.

The course is indicated by markers A, B and C.

The total length of the course is 1500 metres.

- B is 600 metres from A
- C is 650 metres from A
- C is due north of B



Determine whether B is due east of A.

Justify your answer.

4

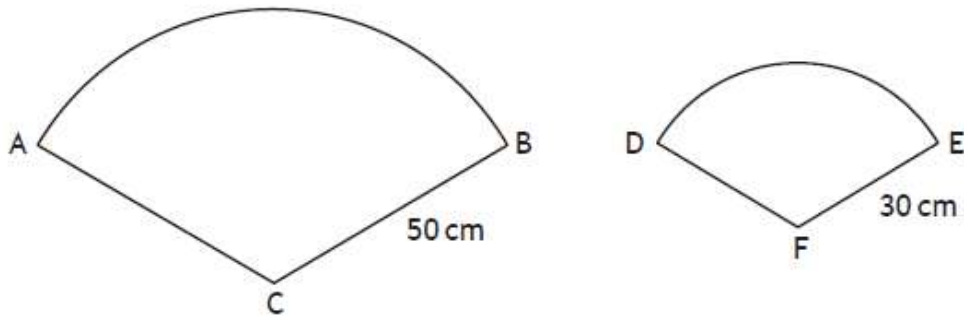
$$\begin{aligned} & 1500 - (600 + 650) && 650^2 = 422500 \quad \checkmark \\ = & \underline{\underline{250}} && 600^2 + 250^2 = 422500 \quad \checkmark \end{aligned}$$

As  $650^2 = 600^2 + 250^2$ , ABC is right angled at B, and B is due east of A.  $\checkmark$



12. In the diagram

- ABC is a sector of a circle, centre C
- DEF is a sector of a circle, centre F.



The sectors are mathematically similar.

The area of the larger sector, ABC, is 2750 square centimetres.

(a) Calculate the area of the smaller sector, DEF.

3

$$SF = \frac{30}{50} = \frac{3}{5} \quad \text{Area} = 2750 \times SF^2$$
$$= 2750 \times \left(\frac{3}{5}\right)^2$$
$$= \underline{990 \text{ cm}^2}$$

(b) Calculate the size of angle ACB.

3

$$\frac{ACB}{360} = \frac{2750}{\pi(50)^2}$$
$$ACB = \frac{360 \times 2750}{\pi \times 2500}$$
$$= \underline{\underline{126^\circ}}$$



13. Find an expression for the gradient of the line joining point A(6,9) to point B(4p,4p<sup>2</sup>).

Give your answer in its simplest form.

3

$$m = \frac{4p^2 - 9}{4p - 6} = \frac{(2p+3)(2p-3)}{2(2p-3)} = \frac{2p+3}{2}$$

14. Solve the equation  $5\cos x^\circ + 2 = 1$ ,  $0 \leq x < 360$ .

3

$$\begin{aligned} 5\cos x &= -1 \\ \cos x &= -\frac{1}{5} \\ x &= \cos^{-1}\left(\frac{1}{5}\right) \\ x &= 78.5^\circ \end{aligned}$$

$$\begin{array}{c|c} 180 - x & \text{S} \\ \hline & \text{T} \\ 180 + x & \end{array}$$

$$\underline{\underline{x = 101.5^\circ, 258.5^\circ}}$$

15. Express

$$\frac{4}{x-2} - \frac{3}{x+5}, \quad x \neq 2, x \neq -5$$

as a single fraction in its simplest form.

3

$$\begin{aligned} \frac{4(x+5) - 3(x-2)}{(x-2)(x+5)} &= \frac{4x+20 - 3x+6}{(x-2)(x+5)} \\ &= \frac{x+26}{(x-2)(x+5)} \end{aligned}$$

16. Simplify  $\frac{a^4 \times 3a}{\sqrt{a}}$ .  $= \frac{3a^5}{a^{1/2}} = \underline{\underline{3a^{9/2}}}$

3

17. Expand and simplify

$$(\sin x^\circ + \cos x^\circ)^2.$$

Show your working.

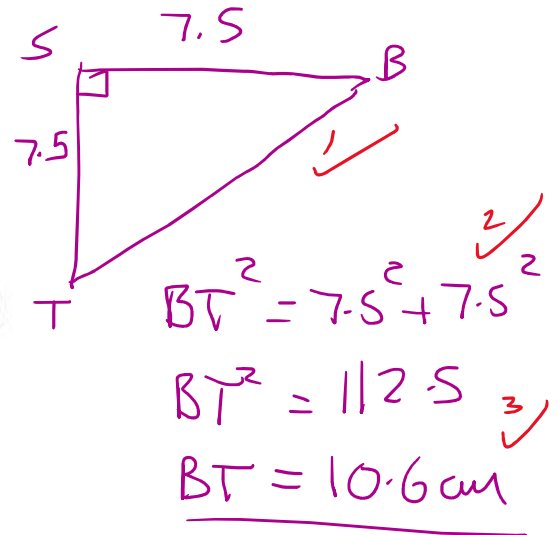
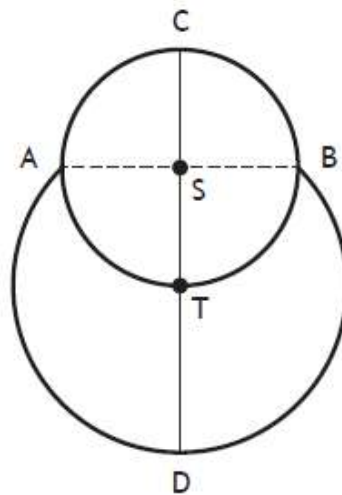
2

$$\begin{aligned} & (\sin x + \cos x)(\sin x + \cos x) \\ &= \sin x (\sin x + \cos x) + \cos x (\sin x + \cos x) \\ &= \sin^2 x + \sin x \cos x + \sin x \cos x + \cos^2 x \\ &= 2 \sin x \cos x + \sin^2 x + \cos^2 x \\ &= \underline{\underline{2 \sin x \cos x + 1}} \end{aligned}$$

18. The picture shows a cartoon snowman.



The diagram below represents the snowman.



- The head is a small circle, centre S, with diameter 15 centimetres
- The body is part of a larger circle, centre T
- The point T lies on the circumference of the small circle
- The points A and B lie on the circumferences of both circles

Calculate CD, the height of the snowman.

4

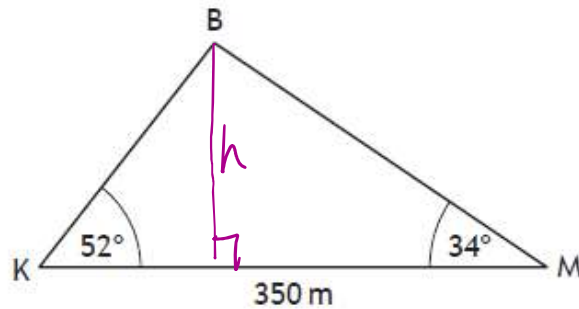
$$BT = TD \text{ (both radii)}$$

$$\begin{aligned} \therefore CD &= CT + TD \\ &= 15 + 10.6 \\ &= 25.6 \end{aligned}$$

$$\therefore \underline{\underline{25.6 \text{ cm}}}$$

19. Katy and Mona are looking up at a hot-air balloon.

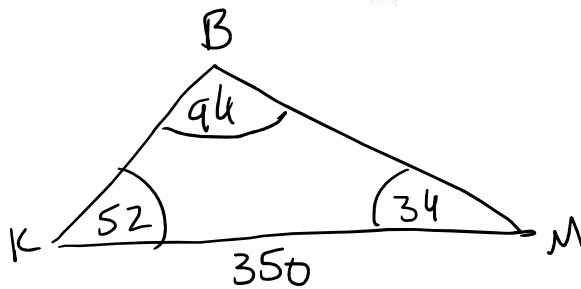
In the diagram below, K, M and B represent the positions of Katy, Mona and the balloon respectively.



- The angle of elevation of the balloon from Katy is  $52^\circ$
- The angle of elevation of the balloon from Mona is  $34^\circ$
- Katy and Mona are 350 metres apart on level ground

Calculate the height of the hot-air balloon above the ground.

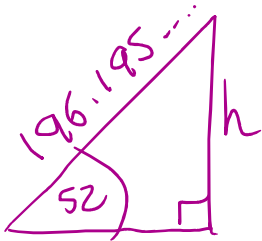
5



$$\frac{M}{\sin 34} = \frac{350}{\sin 94} \quad 1 \checkmark$$

$$M = \frac{350 \sin 34}{\sin 94} \quad 2 \checkmark$$

$$M = 196.195\dots \quad 3 \checkmark$$



$$\frac{h}{196.195\dots} = \sin 52$$

$$h = 196.195\dots \times \sin 52 \quad 4 \checkmark$$

$$\underline{h = 156.6 \text{ m}} \quad 5 \checkmark$$