

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname StemUp Model Solution

Forename(s) _____

Candidate signature _____

I declare this is my own work.

GCSE MATHEMATICS

H

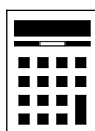
Higher Tier Paper 3 Calculator

Monday 13 November 2023 Morning Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a calculator
- mathematical instruments
- the Formulae Sheet (enclosed).



Instructions

- Use black ink or black ball-point pen. Draw diagrams in pencil.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.
- You may ask for more answer paper, graph paper and tracing paper. These must be tagged securely to this answer book.

Advice

In all calculations, show clearly how you work out your answer.

For Examiner's Use

Pages	Mark
2–3	
4–5	
6–7	
8–9	
10–11	
12–13	
14–15	
16–17	
18–19	
20–21	
22–23	
24–25	
26	
TOTAL	



N 0 V 2 3 8 3 0 0 3 H 0 1

Answer **all** questions in the spaces provided.

- 1** The first four terms of a linear sequence are

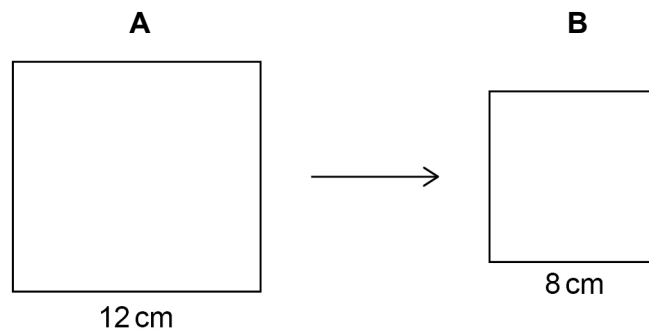
6 13 20 27

Write down the expression for the n th term.

[1 mark]

Answer $7n - 1$

- 2** Square A is enlarged to square B.



Not drawn
accurately

Write down the scale factor of the enlargement as a fraction.

[1 mark]

Scale factor = $8 \div 12 = 8/12 = 2/3$

Answer $\frac{2}{3}$



- 3 The length of a line is 8 cm to the nearest centimetre.

Complete the error interval.

[2 marks]

Half of 1 cm = 0.5 cm, $8 - 0.5 = 7.5$ and $8 + 0.5 = 8.5$

Answer 7.5 cm $\leq$ length < 8.5 cm

- 4 At what point does the graph $y = x^3 - 1$ cross the y axis?

[1 mark]

Answer (0 , -1)

Turn over for the next question

Turn over ►



5 Carly's total annual pay = salary + bonus

	Salary	Bonus
Last year	£26 000	£4000
This year	6% increase	9% decrease

Work out the percentage change in her total annual pay.

State whether it is an increase or a decrease.

[4 marks]

$$\text{Last year total} = 26\,000 + 4000 = \text{£}30\,000$$

$$\text{Salary this year} = 26\,000 \times 1.06 = \text{£}27\,560$$

$$\text{Bonus this year} = 4000 \times 0.91 = \text{£}3640$$

$$\text{Total this year} = 27\,560 + 3640 = \text{£}31\,200$$

$$31\,200 \div 30\,000 = 1.04$$

$$1.04 - 1 = 0.04 = 4\%$$

Total pay has gone up, so it is an increase of 4%

Answer 4% increase



6

An exhibition

was open for 240 hours

and

had 29 760 visitors.

For $\frac{2}{5}$ of the time the exhibition was open, there were 172 visitors per hour.

For the remaining time, how many visitors per hour were there?

[4 marks]

$$\text{Time at 172 per hour} = \frac{2}{5} \times 240 = 96 \text{ hours}$$

$$\text{Visitors in this time} = 96 \times 172 = 16\,512$$

$$\text{Remaining visitors} = 29\,760 - 16\,512 = 13\,248$$

$$\text{Remaining time} = 240 - 96 = 144 \text{ hours}$$

$$\text{Visitors per hour} = 13\,248 \div 144 = 92$$

Answer 92

7

The first two cube numbers are 1 and 8

Show that

the 3rd cube number can be written as the sum of three different prime numbers.

[3 marks]

$$\text{3rd cube number} = 3^3 = 27$$

$$\boxed{27} = \boxed{3} + \boxed{5} + \boxed{19}$$

Turn over ►



- 8 Circle the largest number.

[1 mark]

5.30 $\dot{4}$

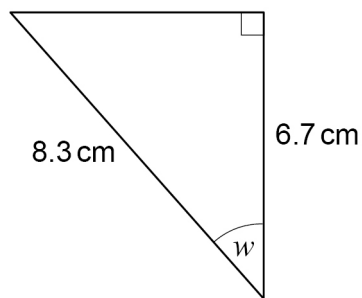
5.344

5.34

5.3 $\dot{4}$

- 9 Use trigonometry to work out the size of angle w .

[3 marks]



Not drawn
accurately

$$\cos w = \frac{\text{adj}}{\text{hyp}} = \frac{6.7}{8.3}$$

$$w = \cos^{-1}(6.7 \div 8.3)$$

$$w = 36.17393\dots$$

$$w = 36.2^\circ \text{ (1 dp)}$$

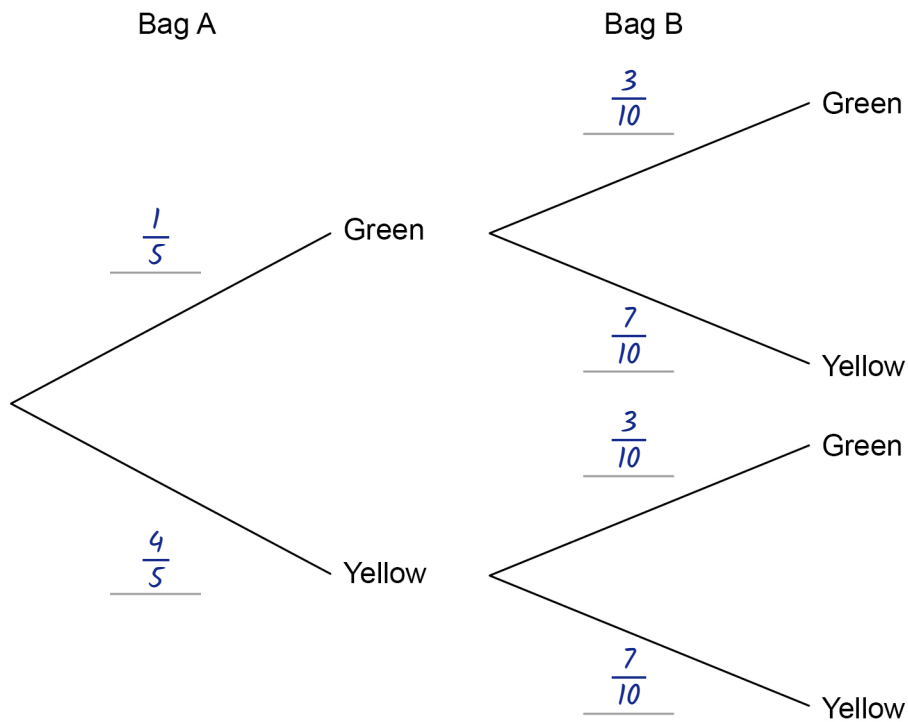
$$w = \underline{\quad 36.2 \quad}^\circ$$



- 10** Two bags contain only green discs and yellow discs.
 Bag A contains 1 green disc and 4 yellow discs.
 Bag B contains 3 green discs and 7 yellow discs.
 One disc is picked at random from each bag.

- 10 (a)** Complete the tree diagram with the correct probabilities.

[2 marks]



- 10 (b)** Work out the probability that **both** discs are green.

[2 marks]

$$P(G, G) = \frac{1}{5} \times \frac{3}{10} = \frac{3}{50}$$

Answer $\frac{3}{50}$



11

Solve these simultaneous equations.

$$7x + 2y = 100$$

$$3x + 2y = 48$$

[3 marks]

$$(7x + 2y) - (3x + 2y) = 100 - 48$$

$$4x = 52$$

$$x = 52 \div 4 = 13$$

Substitute into $3x + 2y = 48$:

$$3 \times 13 + 2y = 48 \rightarrow 39 + 2y = 48$$

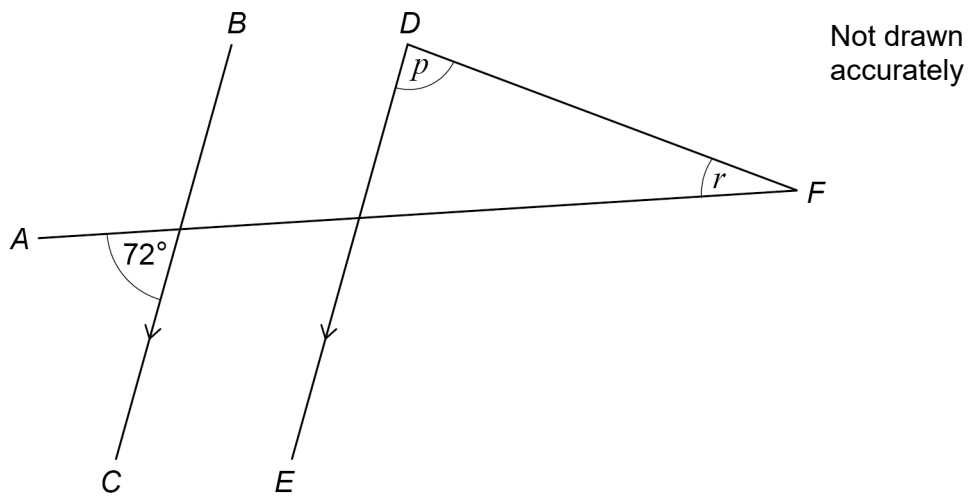
$$2y = 9$$

$$y = 4.5$$

$$x = \underline{13} \quad y = \underline{4.5}$$



12

 AF , BC , DE and DF are straight lines. BC and DE are parallel. p is three times r .Work out the size of angle p .**[3 marks]**

Corresponding angles are equal and vertically opposite angles are equal, so the angle in the triangle at the crossing of AF and DE is 72°

Angles in a triangle add up to 180° : $p + r + 72 = 180$

$3r + r = 180 - 72 \rightarrow 4r = 108$

$r = 108 \div 4 = 27$

$p = 3 \times 27 = 81$

$p = \underline{\hspace{2cm} 81 \hspace{2cm}}^\circ$



- 13** 100 people were asked about the distance they travel from home to work.
The table shows information about the results.

Distance, d (miles)	Frequency
$0 \leq d < 5$	21
$5 \leq d < 10$	24
$10 \leq d < 20$	37
$20 \leq d < 40$	18

- 13 (a)** Write down the **greatest** possible number of people who work from home.

[1 mark]

Answer 21

- 13 (b)** One person is chosen at random.

Work out the probability that the person travels **at least** 10 miles.

[1 mark]

At least 10 miles: $37 + 18 = 55$ people out of 100

Answer $\frac{55}{100}$

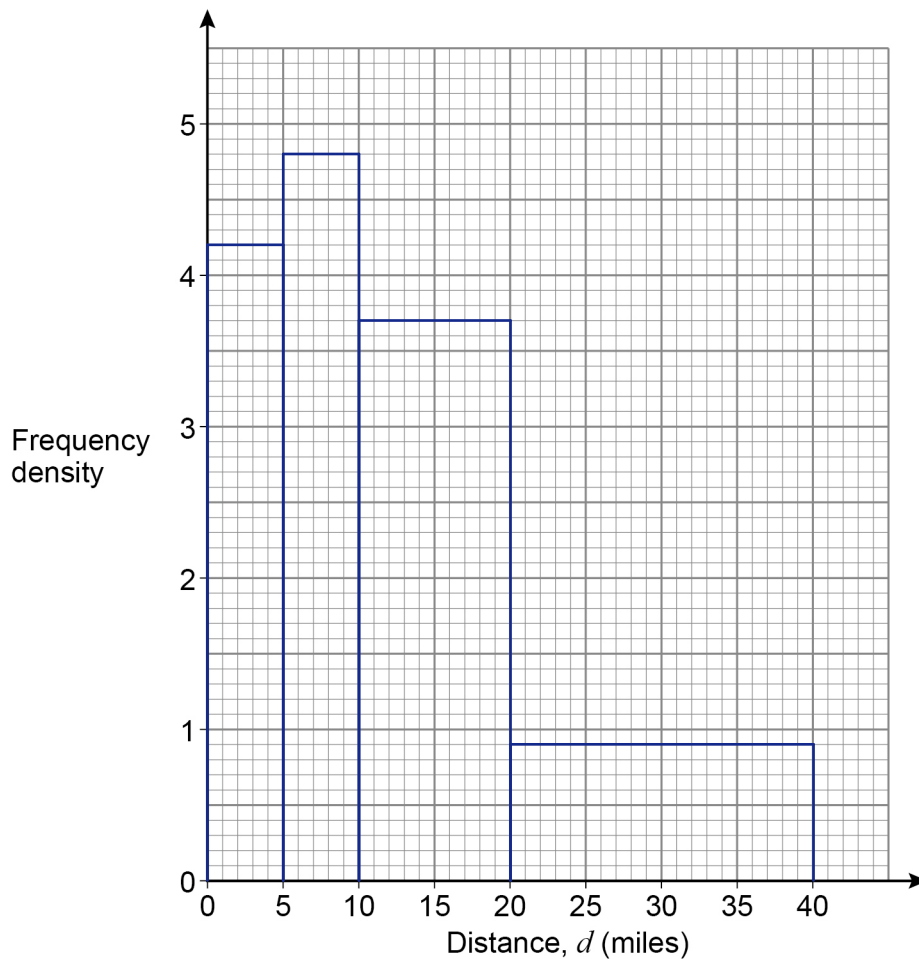


13 (c) The table is repeated.

Distance, d (miles)	Frequency	Frequency density
$0 \leq d < 5$	21	$21 \div 5 = 4.2$
$5 \leq d < 10$	24	$24 \div 5 = 4.8$
$10 \leq d < 20$	37	$37 \div 10 = 3.7$
$20 \leq d < 40$	18	$18 \div 20 = 0.9$

Draw a histogram to represent the results.

[3 marks]



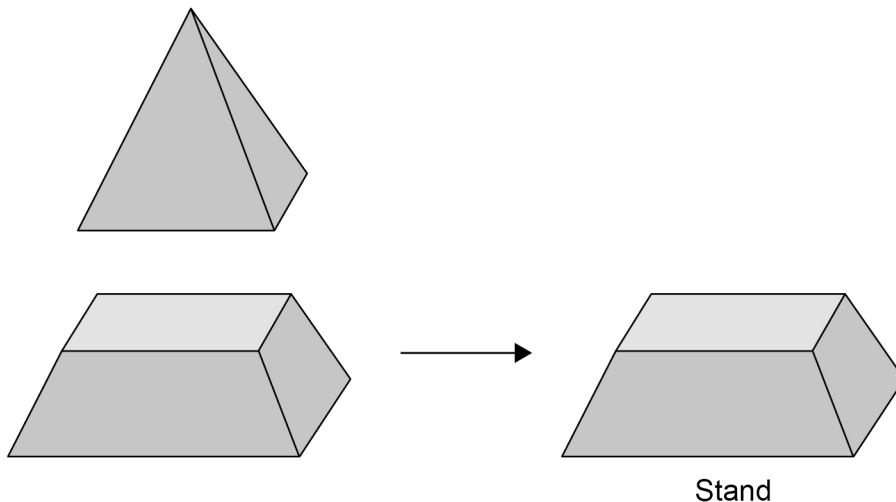
- 14 A solid trophy consists of a stand and a player.



Trophy

The stand is made by removing a small pyramid from a large pyramid.

Large pyramid	Square base, edge 8 cm	Perpendicular height 16 cm
Small pyramid	Square base, edge 5 cm	Perpendicular height 10 cm



Stand

$$\text{Volume of a pyramid} = \frac{1}{3} \times \text{area of base} \times \text{perpendicular height}$$



- 14 (a) Show that the volume of the **stand** is 258 cm^3

[2 marks]

$$\text{Large pyramid} = \frac{1}{3} \times 8 \times 8 \times 16 = \frac{1024}{3}$$

$$\text{Small pyramid} = \frac{1}{3} \times 5 \times 5 \times 10 = \frac{250}{3}$$

$$\text{Stand} = \frac{1024}{3} - \frac{250}{3} = \frac{774}{3} = 258 \text{ cm}^3$$

- 14 (b) The trophy is made from a metal of density $7.5 \text{ grams per cm}^3$
The **total** mass of the trophy is 2340 grams .

Work out the volume of the **player**.

[2 marks]

$$\text{Total volume} = 2340 \div 7.5 = 312 \text{ cm}^3$$

$$\text{Volume of player} = 312 - 258 = 54 \text{ cm}^3$$

Answer 54 cm^3

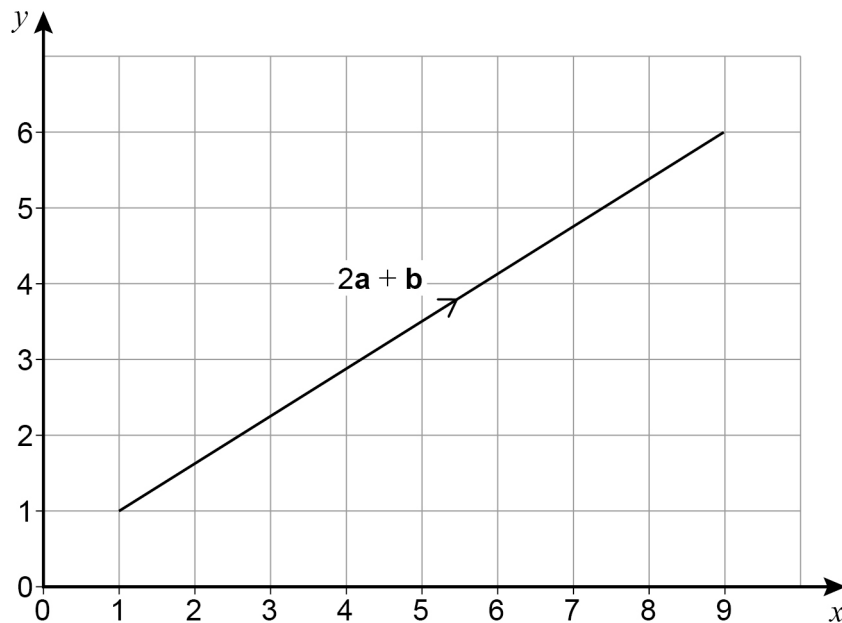
Turn over ►



15

$$\mathbf{a} = \begin{pmatrix} m \\ 3 \end{pmatrix} \quad \mathbf{b} = \begin{pmatrix} -4 \\ p \end{pmatrix}$$

The diagram shows the vector $2\mathbf{a} + \mathbf{b}$



Work out the values of m and p .

[4 marks]

From the diagram, $2\mathbf{a} + \mathbf{b}$ goes from (1, 1) to (9, 6)

$$2\mathbf{a} + \mathbf{b} = \begin{pmatrix} 8 \\ 5 \end{pmatrix}$$

$$2\mathbf{a} + \mathbf{b} = 2 \begin{pmatrix} m \\ 3 \end{pmatrix} + \begin{pmatrix} -4 \\ p \end{pmatrix} = \begin{pmatrix} 2m - 4 \\ 6 + p \end{pmatrix}$$

$$2m - 4 = 8 \rightarrow 2m = 12 \rightarrow m = 6$$

$$6 + p = 5 \rightarrow p = -1$$

$$m = \underline{\quad 6 \quad} \quad p = \underline{\quad -1 \quad}$$

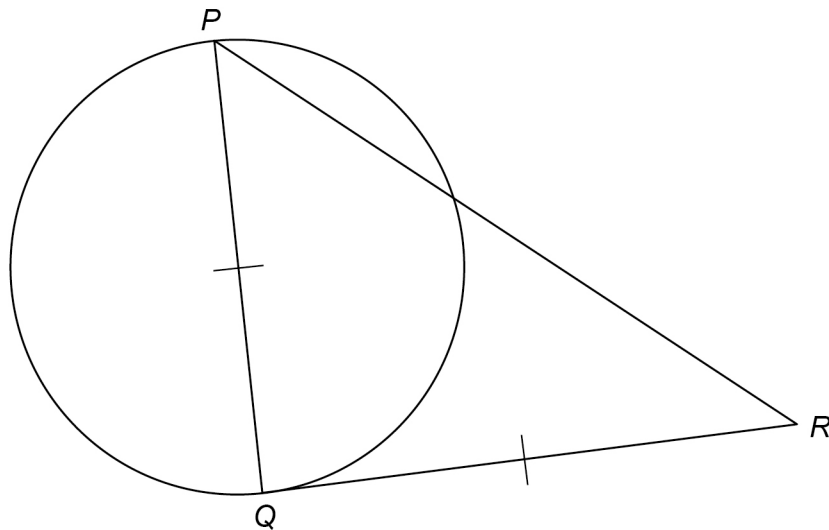


16

 PQ is a diameter of a circle. QR is a tangent to the circle.

$$PQ = QR$$

$$PR = 10 \text{ cm}$$

Not drawn
accuratelyWork out the **radius** of the circle.

Give your answer as a decimal.

[3 marks]*Angle $PQR = 90^\circ$ (tangent meets the radius/diameter at 90°)**Let $PQ = QR = d$. Pythagoras: $d^2 + d^2 = 10^2$*

$2d^2 = 100 \rightarrow d^2 = 50$

$d = \sqrt{50} = 7.071067\dots$

$\text{radius} = d \div 2 = 7.071067\dots \div 2 = 3.535533\dots$

$\text{radius} = 3.54 \text{ cm (3 sf)}$

Answer 3.54 cm

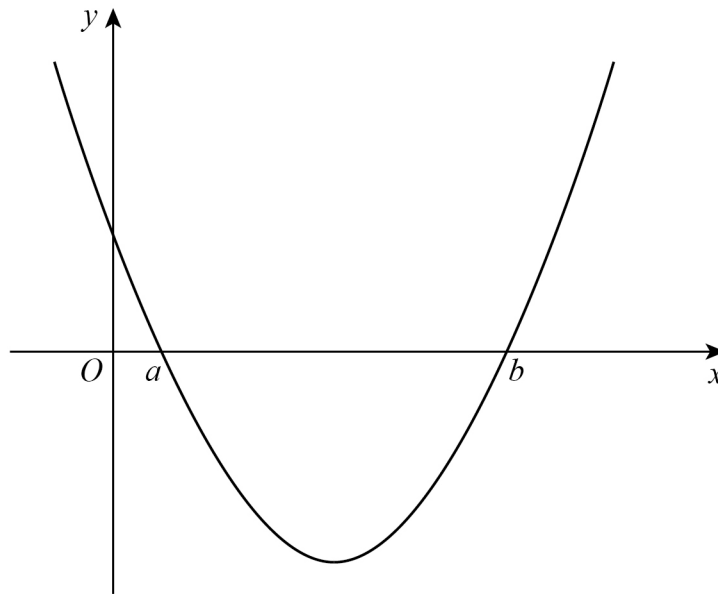
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17

Here is a sketch of the quadratic graph $y = f(x)$

The graph crosses the x -axis at $x = a$ and $x = b$



Write an expression for the x -coordinate of the turning point.

[1 mark]

Answer $\frac{a + b}{2}$



18

Simplify $\frac{2(x+4)^5}{(x+4)^3}$ Give your answer in the form $ax^2 + bx + c$ where a , b and c are integers.**[3 marks]**

$$2(x+4)^5 \div (x+4)^3 = 2(x+4)^2$$

$$(x+4)^2 = (x+4)(x+4) = x^2 + 4x + 4x + 16$$

$$= x^2 + 8x + 16$$

$$2(x^2 + 8x + 16) = 2x^2 + 16x + 32$$

Answer $2x^2 + 16x + 32$

Turn over for the next question

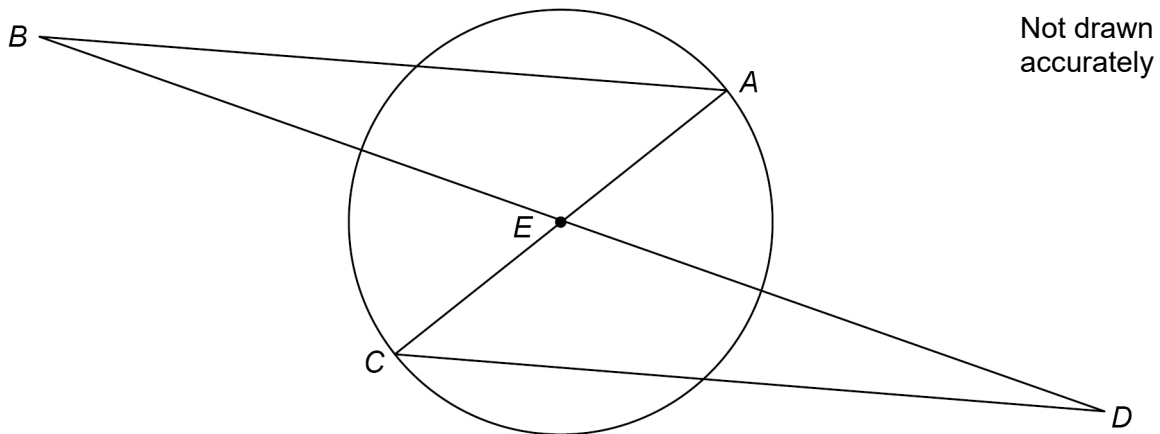
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19

AC is a diameter of a circle, centre E .

E is the midpoint of BD .



Prove that triangle ABE is congruent to triangle CDE .

[4 marks]

$AE = CE$ (both are radii of the circle)

$BE = DE$ (E is the midpoint of BD)

Angle $AEB = \text{angle } CED$ (vertically opposite angles are equal)

Two sides and the included angle are equal,

so triangle ABE is congruent to triangle CDE (SAS)



20 Solve $2x(x + 10) = 5x - 18$

[4 marks]

$$2x^2 + 20x = 5x - 18$$

$$2x^2 + 20x - 5x + 18 = 0$$

$$2x^2 + 15x + 18 = 0$$

$$(2x + 3)(x + 6) = 0$$

$$2x + 3 = 0 \text{ or } x + 6 = 0$$

$$x = -1.5 \text{ or } x = -6$$

Answer $x = -1.5 \text{ or } x = -6$

Turn over for the next question

Turn over ►

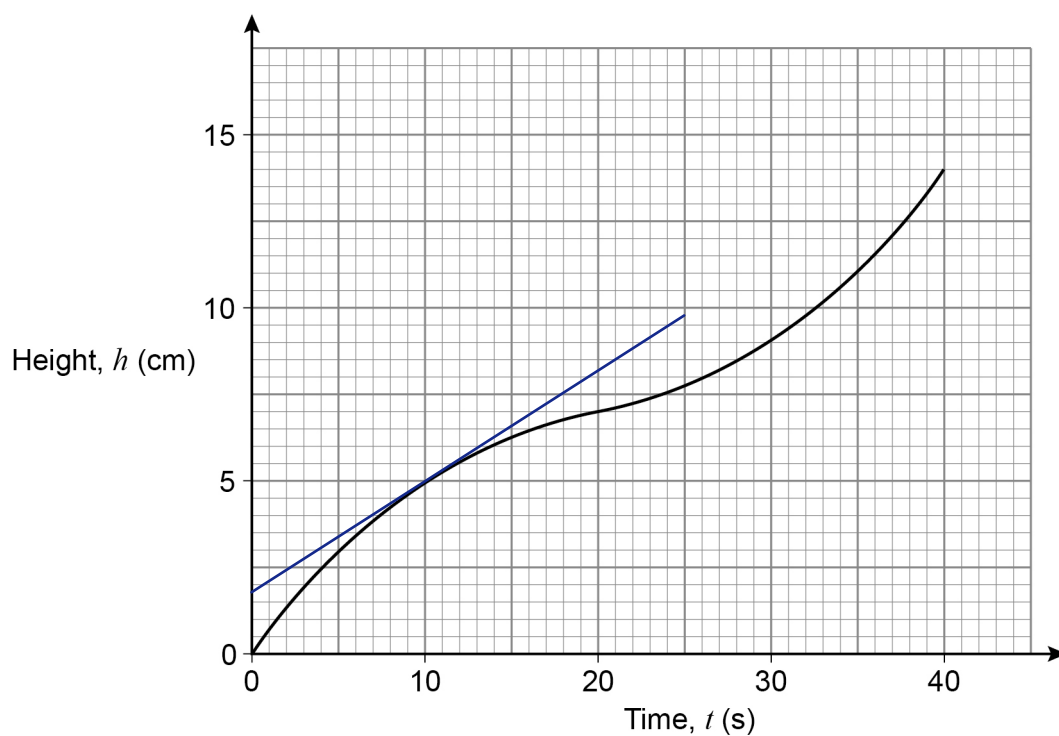


21

Water flows from a tap at a constant rate.

A container is filled with water from the tap in 40 seconds.

The graph shows the height, h centimetres, of the water after time, t seconds.

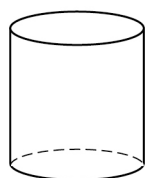


21 (a) The container is one of these shapes.

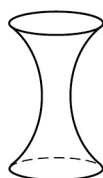
Circle the letter of the correct shape.

[1 mark]

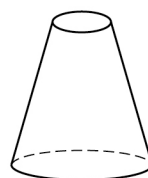
A



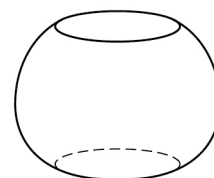
B



C



D



- 21 (b) By drawing a tangent on the graph,
estimate the rate at which the height is increasing when $t = 10$

[2 marks]

Tangent at $t = 10$ passes through $(0, 1.8)$ and $(25, 9.8)$

$$\text{gradient} = (9.8 - 1.8) \div (25 - 0) = 8 \div 25$$

$$= 0.32$$

Answer 0.32 cm/s

- 22 Write $\frac{7}{2a^2} - \frac{3}{5a}$ as a single fraction in its simplest form.

[2 marks]

$$\frac{7}{2a^2} - \frac{3}{5a} = \frac{7 \times 5}{10a^2} - \frac{3 \times 2a}{10a^2} = \frac{35}{10a^2} - \frac{6a}{10a^2}$$

$$= \frac{35 - 6a}{10a^2}$$

Answer $\frac{35 - 6a}{10a^2}$



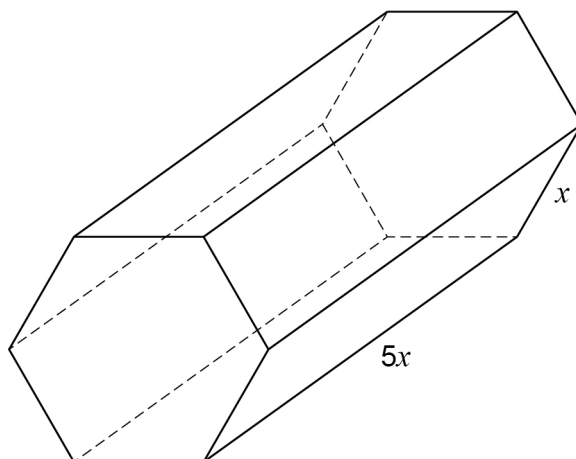
23

A chocolate box in the shape of a prism is being designed.

All lengths are in centimetres.

The cross section is a regular hexagon with side x

The length is $5x$



An expression for the area of the cross section, in cm^2 , is $\frac{3\sqrt{3}}{2}x^2$

The **total** surface area of the box must be less than 650 cm^2

Work out the largest possible **integer** value of x .

You **must** show your working.

[4 marks]

$$\text{Two hexagons: } 2 \times \left(\frac{3\sqrt{3}}{2}\right)x^2 = 3\sqrt{3}x^2$$

$$\text{Six rectangles: } 6 \times x \times 5x = 30x^2$$

$$\text{Total surface area} = 3\sqrt{3}x^2 + 30x^2 = 35.196\dots x^2$$

$$35.196\dots x^2 < 650 \rightarrow x^2 < 650 \div 35.196\dots = 18.467\dots$$

$$x < \sqrt{18.467\dots} = 4.297\dots$$

$$\text{Check: } x = 4: 35.196\dots \times 16 = 563.1\dots < 650$$

$$x = 5: 35.196\dots \times 25 = 879.9\dots > 650$$

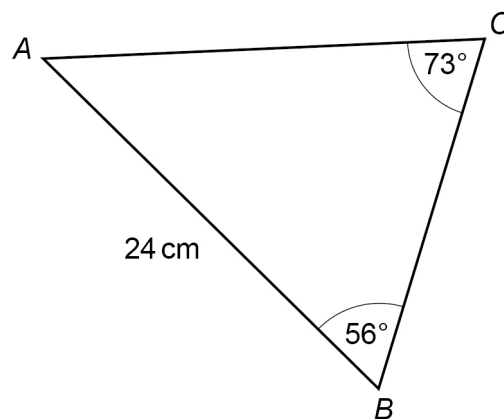
Largest integer value is $x = 4$

Answer 4



24

Work out the area of triangle ABC.

[4 marks]Not drawn
accurately

$$\text{Angle } A = 180^\circ - 56^\circ - 73^\circ = 51^\circ$$

$$\text{Sine rule: } AC \div \sin 56^\circ = 24 \div \sin 73^\circ$$

$$AC = 24 \times \sin 56^\circ \div \sin 73^\circ = 20.806026\dots$$

$$\text{Area} = \frac{1}{2} \times AB \times AC \times \sin A$$

$$= 0.5 \times 24 \times 20.806026\dots \times \sin 51^\circ$$

$$= 194.03183\dots$$

$$= 194 \text{ cm}^2 \text{ (3 sf)}$$

Answer 194 cm²

Turn over ►



25

 a is three quarters of c

$$6b = 5c$$

Work out the ratio $a : b : c$ Give your answer in its simplest form, where a , b and c are integers.**[3 marks]**

$$a = \frac{3}{4}c \quad \text{and} \quad b = \frac{5}{6}c$$

$$a : b : c = \frac{3}{4} : \frac{5}{6} : 1$$

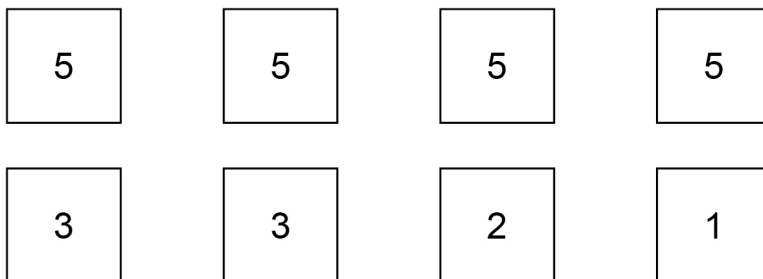
$$\times 12: \quad = 9 : 10 : 12$$

$$(\text{check: } 9 = \frac{3}{4} \times 12 \text{ and } 6 \times 10 = 60 = 5 \times 12)$$

Answer 9 : 10 : 12

26

In a game, these numbered tiles are in a bag.

**To play the game**

Choose tiles at random one at a time and do not replace the tiles.
You win if at any stage the total of the numbers on your tiles is 10

Amber plays the game once.

Work out the probability that she wins.

[4 marks]

$$\text{Win with 5, 5 (first two tiles): } \frac{4}{8} \times \frac{3}{7} = \frac{12}{56} = \frac{3}{14}$$

Win with 5, 3, 2 in some order, eg 5 then 3 then 2:

$$\frac{4}{8} \times \frac{2}{7} \times \frac{1}{6} = \frac{8}{336} = \frac{1}{42}$$

$$\text{There are } 3! = 6 \text{ orders: } 6 \times \frac{1}{42} = \frac{6}{42}$$

(No other way makes exactly 10, eg the 1 can never be used)

$$P(\text{win}) = \frac{3}{14} + \frac{1}{7} = \frac{3}{14} + \frac{2}{14} = \frac{5}{14}$$

Answer $\frac{5}{14}$

7

Turn over ►



- 27 (a) The graph of $y = x^3$ is translated to the graph of $y = (x - 2)^3$

Write down the translation vector.

[1 mark]

Answer $\begin{pmatrix} 2 \\ 0 \end{pmatrix}$

- 27 (b) The graph of $y = 5x + 4$ is reflected in the y -axis.

Write down the equation of the reflected graph.

[1 mark]

Answer $y = -5x + 4$

END OF QUESTIONS



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3 2



2 3 B G 8 3 0 0 / 3 H