AQA

.CG Maths.
Worked Solutions

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname ____________________

Forename(s) ____________________

Candidate signature ____________________

GCSE MATHEMATICS

H

Higher Tier   Paper 3 Calculator

Monday 12 November 2018   Morning   Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:
- a calculator
- mathematical instruments.

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.
- 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	

Please note that these worked solutions have neither been provided nor approved by AQA and may not necessarily constitute the only possible solutions. Please refer to the original mark schemes for full guidance.

Any writing in blue indicates what must be written in order to answer the questions and get the marks. The worked solutions have been designed to show the smallest amount of work which needs to be done to answer the question.

Anything written in green in a cloud doesn't have to be written in the exam.

Anything written in orange in a rectangle doesn't have to be written in the exam and is there to show what should be put into a calculator or measured using a ruler or protractor.

If you find any mistakes or have any requests or suggestions, please send an email to curtis@cgmaths.co.uk

Do not write outside the box

Answer **all** questions in the spaces provided

1 A shape is translated by the vector $\begin{pmatrix} 0 \\ 4 \end{pmatrix}$

In which direction does the shape move?

Circle your answer.

[1 mark]

up   down   left   right

The top number of the vector is in the x-direction. The bottom number of the vector is in the y-direction. As it moves 0 in the x-direction it doesn't move left or right. As it is positive in the y-direction it moves up

2 What is 1.75 kilometres as a fraction of 700 metres?

Circle your answer.

[1 mark]

$\frac{5}{2}$ $\frac{1}{4}$ $\frac{4}{1}$ $\frac{2}{5}$

There are 1000 metres in a kilometre so multiplying the 1.75 by 1000 converts it into 1750 metres. Putting 1750/700 into the calculator simplifies the fraction to 5/2

3 The first 4 terms of a linear sequence are

3   11   19   27

Circle the expression for the nth term.

[1 mark]

$8 - 5n$ $n + 8$ $8n + 3$ $8n - 5$

Each term increases by 8 so it must involve 8n. The 0th term (the one which would be before the 1st term) is -5 as the sequence decreases by 8 each time if followed backwards and 3 - 8 = -5. So the sequence must be 8n - 5

Do not write outside the box

4 Work out the lowest common multiple (LCM) of 20, 30 and 40

Circle your answer.

[1 mark]

10 120 240 24 000

This is the smallest number listed which is a multiple of 20, 30 and 40

5 The length of a table is 110 cm to the nearest cm

Complete the error interval.

[2 marks]

$110 \pm \frac{1}{2}$

Adding and subtracting half of the resolution to the 110 cm works out the upper and lower bound. The resolution is 1 cm as this is what it is to the nearest

109.5 cm $\leqslant$ length < 110.5 cm

Turn over for the next question

6

Do not write outside the box

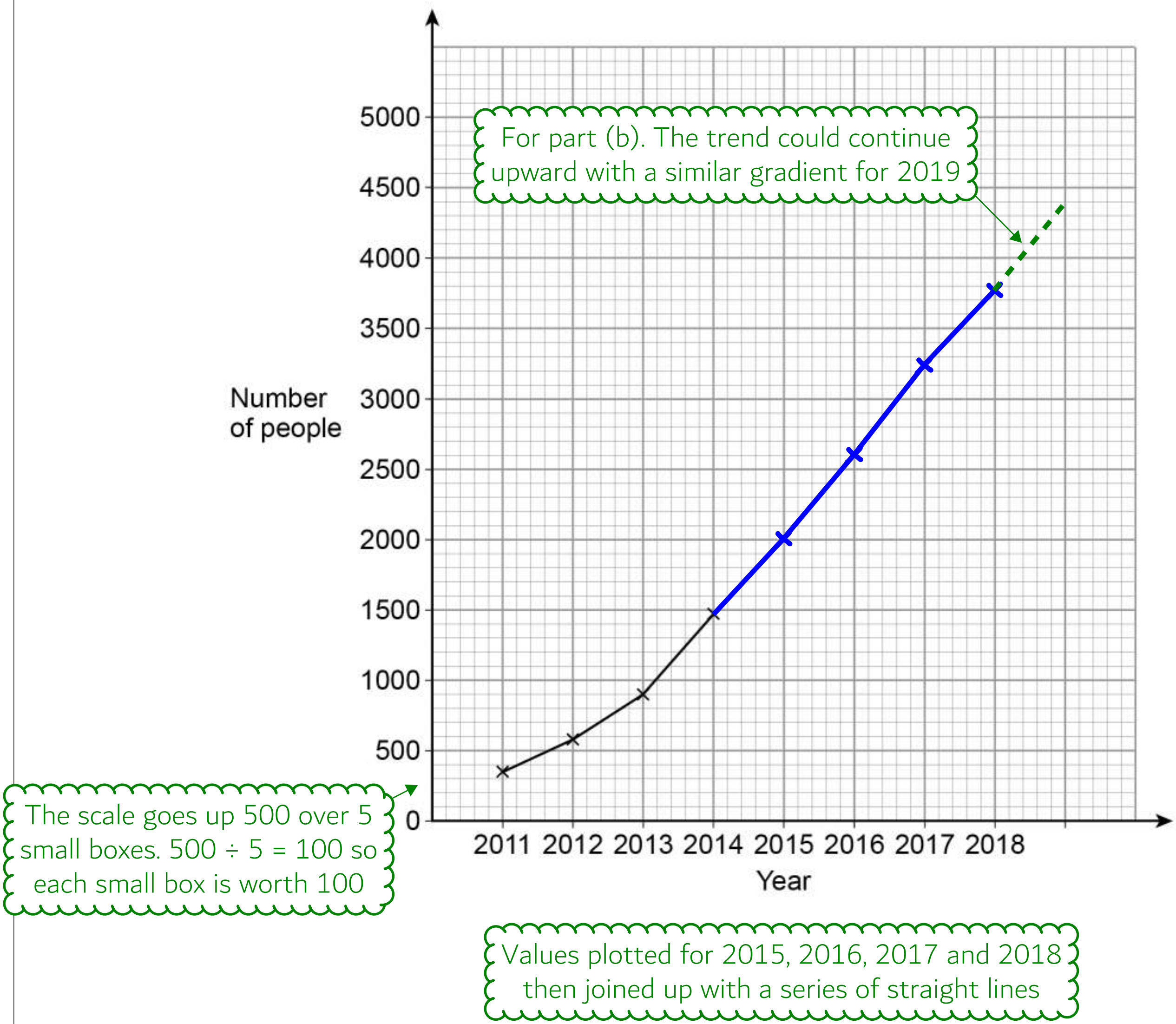
6 A music festival has taken place each year from 2011

The table shows the number of people who attended each year.

Year	2011	2012	2013	2014	2015	2016	2017	2018
Number of people	350	583	906	1471	2023	2612	3251	3780

The festival organisers draw a time series graph to represent the data.

The first four years have been plotted.



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10% is 1/10, which can be found by dividing 14000 by 10. This takes off a 0 to give 1400. Multiplying 10% by 2 gives 20% so 1400 is multiplied by 2

Do not write outside the box

6 (a) Complete the graph.

[2 marks]

6 (b) Use the graph to estimate the number of people who will attend the festival in 2019

[2 marks]

Answer 4400

Turn over for the next question

4

Do not write outside the box

7 $$k = n^2 + 9n + 1$$

Mo says,

"k will be a prime number for all integer values of n from 1 to 9"

Show that Mo is wrong.

You **must** show that your value of k is **not** prime.

[3 marks]

11, 23, 37, 53, 71, 91, 113, 137, 163

Using table mode on the calculator. Set $f(x) = x^2 + 9x + 1$. Start: 1. End: 9. Step: 1. This lists out all of the values of k needed

$91 = 7 \times 13$

Using the calculator to express each of the values of k as a product of prime factors. If it stays the same it is prime. 91 as a product of prime factors is 7 x 13 so it is not prime as it can be divided by both 7 and 13. Prime numbers are only divisible by themselves and 1

Do not write outside the box

8 Doug owes an amount of £600

He wants to pay off this amount in five months.

He says,

"Each month, I will pay back 20% of the amount I still owe."

Show working to check if his method is correct.

[3 marks]

$600 \times \left(\frac{100-20}{100}\right)^5 = 196.61$

Subtracting the 20% from 100% expresses the percentage the amount still owed decreases to each month. Putting this over 100 converts it into a fraction, which when multiplied by the £600 decreases it by 20%. Raising the fraction to the power of 5 as the £600 needs to be decreased by 20% 5 times

No

£196.61 is still owed so the method is not correct

Turn over for the next question

6

Do not write outside the box

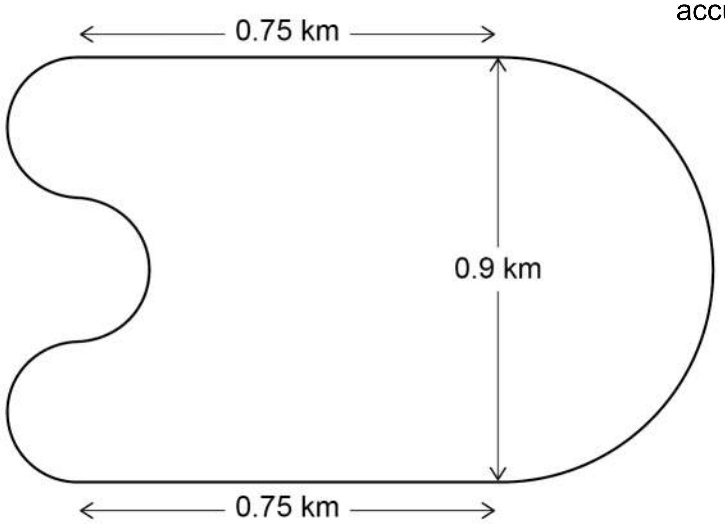
9 A motor racing circuit consists of

two parallel straight sections, each of length 0.75 km

a semicircle of diameter 0.9 km

three equal, smaller semicircles.

Not drawn accurately



The length of a motor race must be greater than 305 km

What is the lowest number of **full** laps needed at this circuit?

You **must** show your working.

[5 marks]

The method is on the next page

Answer 71

$\pi \times 0.9$ ← Circumference = π x diameter. This works out that the circumference of a circle with diameter 0.9 km is 9/10 π km

$\frac{9}{10}\pi \div 2 = \frac{9}{20}\pi$ ← Dividing this circumference by 2 works out that the arc length of the semicircle with diameter of 0.9 km is 9/20 π km

$0.9 \div 3$ ← Dividing the diameter of the larger semicircle by 3 works out that the diameter of each of the smaller semicircles is 0.3 km

$\pi \times 0.3$ ← Circumference = π x diameter. This works out that the circumference of a circle with diameter 0.3 km is 3/10 π km

$\frac{3}{10}\pi \div 2 = \frac{3}{20}\pi$ ← Dividing this circumference by 2 works out that the arc length of the semicircle with diameter of 0.3 km is 3/20 π km

$0.75 \times 2 + \frac{3}{20}\pi \times 3 + \frac{9}{20}\pi$ ← Adding all of the lengths of each section of the track works out that the length of 1 lap is 4.3... km. The 0.75 km is multiplied by 2 as there are 2 of these. The 3/20 π km is multiplied by 3 as there are 3 of these

$305 \div 4.3...$ ← Dividing the minimum length of the race by the length of 1 lap works out that 70.4... laps are needed to do 305 km

$70.4...$ ← The number of laps needs to be a whole number so rounding up to 71 will mean that the race will be more than 305 km

Do not write outside the box

10 Solve $8 > 3 - \frac{1}{2}x$

[2 marks]

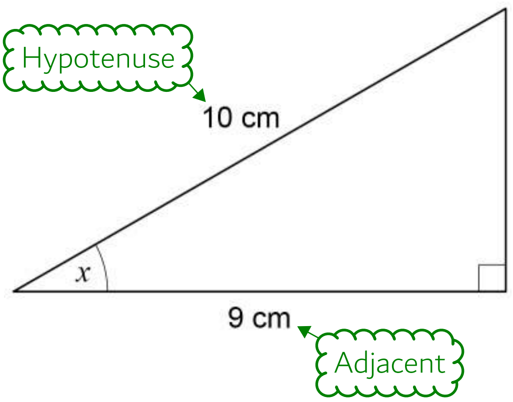
$5 > -\frac{1}{2}x$ ← Subtracting 3 from both sides gets the x term on its own

Answer $-10 < x$

Dividing both sides by -1/2 gets x on its own. Dividing by a negative causes the inequality sign to flip

11 Use trigonometry to work out the size of angle x.

[2 marks]



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$S\frac{O}{H}\ C\frac{A}{H}\ T\frac{O}{A}$ ← Right-angled trigonometry can be used. Ticking A as we have the adjacent and ticking H as we have the hypotenuse. There are two ticks on the CAH formula triangle so this one can be used

$\cos x = \frac{9}{10}$ ← Covering C in the formula triangle finds that cos of the angle = adjacent/hypotenuse

$x = \cos^{-1}\left(\frac{9}{10}\right)$ ← Doing the inverse cos of both sides gets x on its own

Answer 25.8 degrees

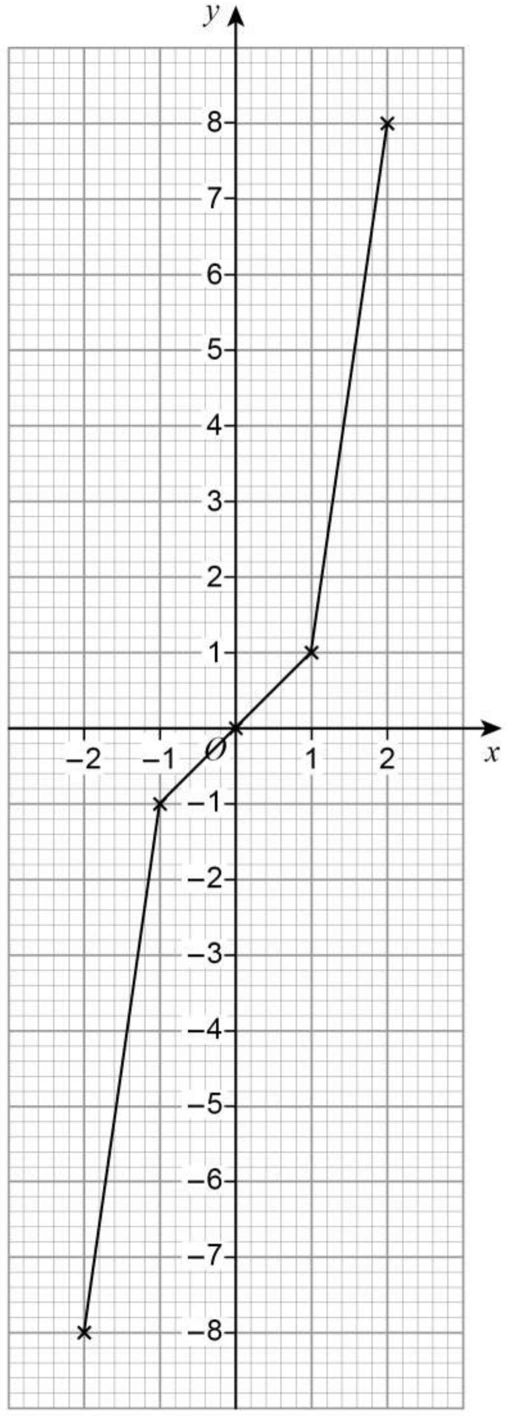
9

Turn over ▶

Do not write outside the box

12 Lewis wants to draw the graph $y = x^3$ for values of x from –2 to 2

Here is his graph.



Make **one** criticism of his graph.

[1 mark]

Should be a curve

The plotted points are correct but everything between them is incorrect. For example, 0.5^3 is not 0.5

Do not write outside the box

13 The probability of Heads when a biased coin is thrown is 0.6

The coin is thrown 500 times.

Circle the expected number of Tails.

[1 mark]

20 200 250 300

0.6 x 500 works out that the expected number of Heads is 300. Subtracting this from 500 gives the expected number of Tails as it can either be Heads or Tails

14 The mean mass of a squad of 19 hockey players is 82 kg

A player of mass 93 kg joins the squad.

Work out the mean mass of the squad now.

[3 marks]

$m^t n$ ← Writing the formula triangle for mean, total, number

82×19 ← Covering t in the formula triangle finds that total = mean x number. So multiplying the mean of 82 kg by the 19 players works out that their total mass is 1558 kg

$1558 + 93$ ← Adding the 93 kg mass of the player who joined to the total of the 19 players works out that the total of all 20 players is 1651 kg

$1651 \div 20$ ← Covering m in the formula triangle finds that mean = total ÷ number. So dividing the total mass of all the players by the 20 players works out the mean mass

Answer 82.55 kg

5

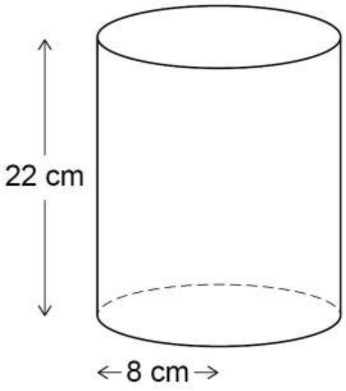
Do not write outside the box

15 A company makes two types of lampshade using fabric on wire frames.

Lampshade A

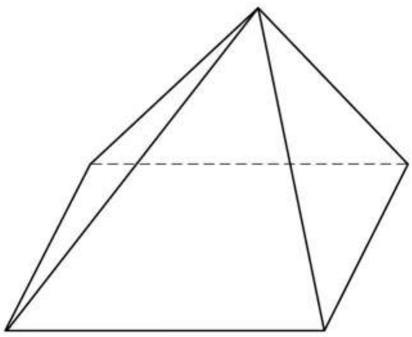
Fabric is used to make the curved surface of a cylinder.

The cylinder has radius 8 cm and height 22 cm

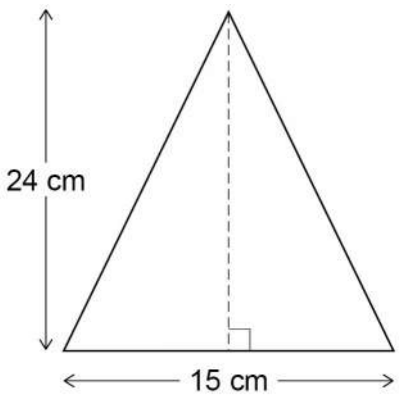


Lampshade B

Fabric is used to make the four triangular faces of a pyramid.



Each triangular face has base 15 cm and perpendicular height 24 cm



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Cost of fabric	£400 per square metre
Other costs for A	£3.50 per lampshade
Other costs for B	£7.50 per lampshade

Work out the ratio cost of one lampshade A : cost of one lampshade B

Give your answer in the form $n : 1$

[5 marks]

Dividing all the lengths in cm by 100 converts them into metres. This needs to be done to work out the area in square metres easier

0.08×2 ← Multiplying the radius of 0.08 m by 2 works out that the diameter of the circle at the base of the cylinder is 0.16 m

$\pi \times 0.16$ ← Circumference = π x diameter

$\frac{4}{25}\pi \times 0.22$ ← Multiplying the circumference of the circle by the height of the cylinder works out that the curved surface area of the cylinder is 0.11... m^2. Think of the curved surface as a curved rectangle. Area of rectangle = length x width. The length is the circumference and the width is the height

$0.11... \times 400$ ← Multiplying the curved surface area of the cylinder (which is the area of the fabric used in lampshade A) by the cost per square metre works out that the cost of the fabric for lampshade A is £44.23 to the nearest penny

$44.23 + 3.50 = 47.73$ ← Adding the other costs for A to the cost of the fabric for A works out that the total cost of one lampshade A is £47.73

$\frac{1}{2} \times 0.15 \times 0.24$ ← Area of triangle = 1/2 x base x height. Using the base of 0.15 m and the height of 0.24 m works out that the area of one of the triangular faces of B is 0.018 m^2

0.018×4 ← Multiplying the area of one triangle face of B by 4 works out that the area of all 4 triangular faces is 0.072 m^2. This is the area of the fabric for B

0.072×400 ← Multiplying the area of the fabric for B by the cost per square metres works out that the cost of the fabric for lampshade B is £28.80

$28.80 + 7.50 = 36.30$ ← Adding the other costs for B to the cost of the fabric for V works out that the total cost of one lampshade V is £36.30

$47.73 \div 36.30$ ← The ratio is 47.73 : 36.30. Dividing both sides by 36.30 gets 1 on the right

Answer 1.31 : 1

5

Do not write outside the box

16 In a running club there are 50 females and 80 males.

If a female is chosen at random, the probability she has blue eyes is 0.38

If a male is chosen at random, the probability he has blue eyes is 0.6

One person is chosen at random.

Show that the probability the person has blue eyes is **more than** 0.5

[4 marks]

$50+80$ Adding the 50 females and 80 males works out that there are 130 people in total

$0.38 \times 50 = 19$ Multiplying the probability a female has blue eyes by the 50 females works out that 19 females have blue eyes

$0.6 \times 80 = 48$ Multiplying the probability a male has blue eyes by the 80 males works out that 48 males have blue eyes

$19+48$ Adding the 19 females with blue eyes and the 48 males with blue eyes works out that there are 67 people with blue eyes

$\frac{67}{130} = 0.51...$ Expressing the fraction of the people who have blue eyes. Putting the 67 people with blue eyes over the 130 people. Converting this to a decimal shows that it is more than 0.5

17 $w = \dfrac{3}{5\sqrt{x}}$

Circle the expression for w^2

[1 mark]

$\dfrac{6}{10x^2}$ $\dfrac{9}{25x^2}$ $\dfrac{6}{10x}$ $\dfrac{9}{25x}$

Squaring w also squares the right side of the equation. To square a fraction, square the numerator and the denominator. $3^2 = 9$. $(5\sqrt{x})^2 = 5^2 \times \sqrt{x}^2 = 25x$. The square root on the $\sqrt{x}$ gets cancelled out as it is squared

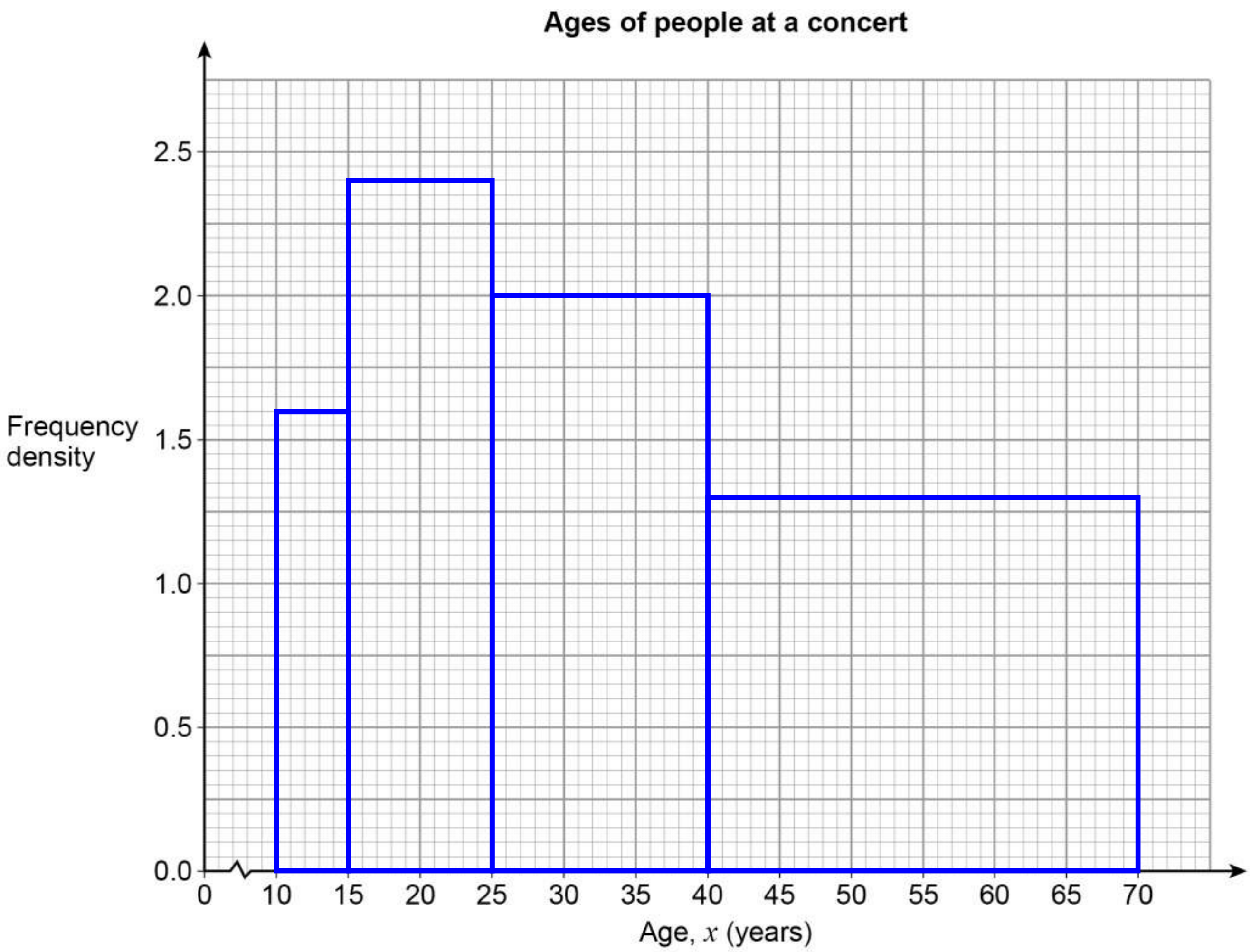
Do not write outside the box

18 Here is some information about the ages of people at a concert.

Age, x (years)	Frequency	
$10 \leqslant x < 15$	8	$\div 5 = 1.6$
$15 \leqslant x < 25$	24	$\div 10 = 2.4$
$25 \leqslant x < 40$	30	$\div 15 = 2$
$40 \leqslant x < 70$	39	$\div 30 = 1.3$

Draw a histogram to represent the information.

[3 marks]



Frequency on a histogram is the area of each bar. Area of rectangle = base x height, so height = area of rectangle ÷ base. The base is the class width, which is the difference between the upper and lower bound of each interval. The height is the frequency density. 10 ⩽ x < 15 has a class width of 5 as 15 - 10 = 5. Dividing the frequency of 8 by this works out that the frequency density is 1.6. 15 ⩽ x < 25 has a class width of 10 as 25 - 15 = 10. Dividing the frequency of 24 by this works out that the frequency density is 2.4. 25 ⩽ x < 40 has a class width of 15 as 40 - 25 = 15. Dividing the frequency of 30 by this works out that the frequency density is 2. 40 ⩽ x < 70 has a class width of 30 as 70 - 40 = 30. Dividing the frequency of 39 by this works out that the frequency density is 1.3

Do not write outside the box

19 The length of a roll of ribbon is 30 metres, correct to the nearest half-metre.

A piece of length 5.8 metres, correct to the nearest 10 centimetres, is cut from the roll.

Work out the maximum possible length of ribbon left on the roll.

[3 marks]

$30+\frac{0.5}{2}=30.25$

The length on the roll needs to be the upper bound. Adding half of the resolution to the 30 works out that the upper bound is 30.25 m. The resolution is 0.5 as it is to the nearest half-metre

$5.8-\frac{0.1}{2}$

The length of the piece cut off needs to be the lower bound. Subtracting half of the resolution from the 5.8 works out that the lower bound is 5.75 m. The resolution is 0.1 as it is to the nearest 10 centimetres. There are 100 cm in 1 m so dividing the 10 cm by 100 converts it to 0.1 m

$30.25-5.75$

Subtracting the lower bound of the length of the piece cut of from the upper bound of the length on the roll works out the maximum possible length of ribbon left on the roll

Answer 24.5 metres

Do not write outside the box

20 Curve P has equation $y = 2(x - 1)^2 - 5$

Curve Q is a reflection in the y-axis of curve P.

Work out the equation of curve Q.

Give your answer in the form $y = ax^2 + bx + c$ where a, b and c are integers.

[3 marks]

$y = 2(-x-1)^2 - 5$ It is a reflection in the y-axis so flipping the sign of all the x

$= 2(x^2 + 2x + 1) - 5$ Expanding out the square bracket by squaring the first term, doubling the product of the two terms, squaring the last term

Answer $y = 2x^2 + 4x - 3$

Expanding out the bracket and subtracting the 5

Turn over for the next question

6

Do not write outside the box

21 Priya and Joe travel the same 16.8 km route.

Priya starts at 9.00 am and walks at a constant speed of 6 km/h

Joe starts at 9.30 am and runs at a constant speed.

Joe overtakes Priya at 10.20 am

At what time does Joe finish the route?

[5 marks]

$s\,{}^{d}\,t$ ← Writing the speed, distance, time formula triangle

$10°20° - 9°$ ← Subtracting 9 hours from 10 hours and 20 minutes works out that it took 1 hour and 20 minutes for Joe to overtake Priya. Putting the times in the calculator as sexagesimals

$6 \times 1°20° = 8$ ← Covering d in the formula triangle finds that distance = speed x time. Multiplying Priya's speed by the 1 hour and 20 minutes works out that Priya had done 8 km when Joe overtook Priya. Joe must also have done 8 km at this point

$10°20° - 9°30°$ ← Subtracting 9 hours and 30 minutes from 10 hours and 20 minutes works out that it took 50 minutes for Joe to overtake Priya

$8 \div 0°50°$ ← Covering s in the formula triangle finds that speed = distance ÷ time. Dividing the 8 km Joe had done when he overtakes by the 0 hours and 50 minutes this took works out that Joe's speed is 9.6 km/h

$16.8 \div 9.6$ ← Covering t in the formula triangle finds that time = distance ÷ speed. Dividing the 16.8 km total distance by the 9.6 km/h speed works out that it took Joe 1.75 hours

$9°30 + 1.75°$ ← Adding 9 hours and 30 minutes and the 1.75 hours gives 11 hours and 15 minutes

Answer 11.15am

↑ Converting 11 hours and 15 minutes back into time format

Do not write outside the box

22 An approximate solution to an equation is found using the iterative formula

$$x_{n+1} = \frac{(x_n)^3 - 2}{10} \quad \text{with} \quad x_1 = -1$$

22 (a) Work out the values of x_2 and x_3

[2 marks]

Enter -1 then press =/exe. Enter (Ans^3 - 2)/10 and press =/exe to get x_2. Press =/exe again to get x_3. This substitutes x_1 into the equation to get x_2 then substitutes this into the equation to get x_3

x_2 = -0.3

x_3 = -0.2027

22 (b) Work out the solution to 5 decimal places.

[1 mark]

Following on from what was done in part (a), keep pressing =/exe until all the decimal places do not change. It should show -0.2008097565

x = -0.20081

8

Turn over ►

Do not write outside the box

23 The diagram shows the side view of a step ladder with a horizontal strut of length 48 cm

The strut is one third of the way up the ladder.

The symmetrical cross section of the ladder shows two similar triangles.

This must be the line of symmetry

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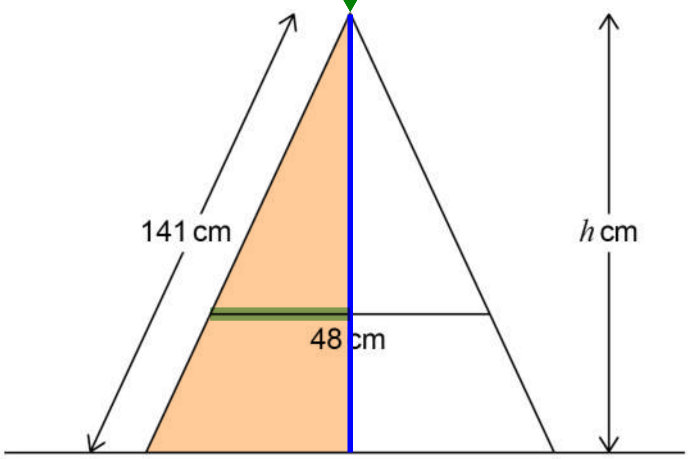

Work out the vertical height, h cm, of the ladder.

[5 marks]

$48 \div 2$ — The line of symmetry cuts the 48 cm in half. So dividing it by 2 works out that the green highlighted length is 24 cm

$x \times \frac{2}{3} = 24$ — Let x be the base length of the orange triangle. The strut is 1/3 of the way up so must be 2/3 of the way down from the top. This is the fraction the smaller triangle is of the larger triangle. So multiplying x by this 2/3 must give the 24 cm

$x = 36$ — Dividing both sides by 2/3 finds that the base length of the orange triangle is 36 cm

$36^2 + h^2 = 141^2$ — Using Pythagoras' Theorem on the orange right-angled triangle. $a^2 + b^2 = c^2$, where a and b are the shorter sides and c is the longest side. Substituting 36 for a, h for b and 141 for c

$h^2 = 18585$ — Subtracting 36^2 from both sides to get the h^2 on its own

Answer 136.3 cm

Square rooting both sides to get h on its own

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24

Volume of a sphere = $\frac{4}{3}\pi r^3$ where r is the radius

Volume of a cone = $\frac{1}{3}\pi r^2 h$ where r is the radius and h is the perpendicular height

A sphere has radius $2x$ cm

A cone has

radius $3x$ cm

perpendicular height h cm

The sphere and the cone have the same volume.

Work out radius of cone : perpendicular height of cone

Give your answer in the form $a : b$ where a and b are integers.

[4 marks]

$$\frac{4}{3}\pi(2x)^3 = \frac{1}{3}\pi(3x)^2 h$$

Setting the volume of the sphere equal to the volume of the cone as they have the same volume. Substituting 2x for r in the volume of the sphere and 3x for r in the volume of the cone

$$\frac{\frac{4}{3}\pi \times 8x^3}{\frac{1}{3}\pi \times 9x^2} = h$$

Dividing both sides by everything h was multiplied by expresses h in terms of x. $(2x)^3 = 8x^3$ and $(3x)^2 = 9x^2$

$$3x : \frac{32}{9}x$$

Putting all the left side into the calculator ignoring the x gives 32/9. $x^3/x^2 = x$ so putting x back in expresses h as 32/9 x. Expressing the ratio of the radius of cone : perpendicular height of cone in terms of x

Dividing both sides of the ratio by x and multiplying both sides by 9 to get rid of the denominator and give integers

Answer 27 : 32

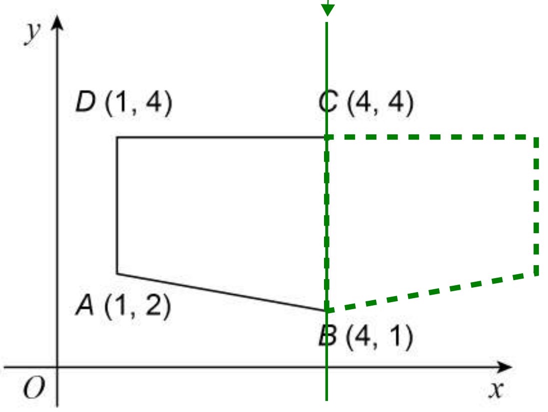
9

Turn over ►

Do not write outside the box

25 *ABCD* is a quadrilateral.

The line of x = 4 must be this as it goes though all points with an x-coordinate of 4



Not drawn accurately

The reflection would look something like this

The quadrilateral is reflected in the line $x = 4$

Which vertices are invariant?

Circle your answer.

[1 mark]

A and *D* *C* and *D* *B* and *C* *B* and *D*

B and C stay in the same place

26 $\qquad f(x) = \dfrac{2x+3}{x-4}$

Work out $f^{-1}(x)$

[4 marks]

$x = \dfrac{2y+3}{y-4}$

f(x) is basically y. The inverse function is when x and y are swapped so doing this then rearranging to make y the subject finds the inverse function

$xy - 4x = 2y + 3$

Multiplying both sides by y - 4 eliminates the denominator on the right. Expanding out x(y - 4) on the left

$xy - 2y = 4x + 3$

Bringing all the terms involving y to the left and everything else to the right. Subtracting 2y and adding 4x to both sides

$y(x-2) = 4x + 3$

Factorising to get y out of both the terms

Answer $\dfrac{4x+3}{x-2}$

Dividing both sides by x - 2 makes y the subject. This is the inverse function

Turn over for the next question

Do not write outside the box

5

27 The line $y = 3x + p$ and the circle $x^2 + y^2 = 53$ intersect at points *A* and *B*.

p is a positive integer.

27 (a) Show that the x-coordinates of points *A* and *B* satisfy the equation

$$10x^2 + 6px + p^2 - 53 = 0$$

[3 marks]

$x^2+(3x+p)^2=53$ Substituting 3x + p for y in the second equation

$x^2+9x^2+6px+p^2-53=0$ Expanding the square bracket by squaring the first term, doubling the product of the two terms, squaring the last term. Subtracting 53 from both sides

$10x^2+6px+p^2-53=0$ Collecting like terms

Do not write outside the box

27 (b) The coordinates of *A* are (2, 7)

Work out the coordinates of *B*.

You **must** show your working.

[5 marks]

$7 = 3(2) + p$ ← A satisfies the equation $y = 3x + p$ so substituting in the x and y-coordinates

$1 = p$ ← Subtracting 3(2) from both sides finds that $p = 1$

$10x^2 + 6x - 52 = 0$ ← Substituting in 1 for p in $10x^2 + 6px + p^2 - 53 = 0$

$x = \frac{-6 \pm \sqrt{6^2 - 4 \times 10 \times -52}}{2 \times 10}$ ← $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ ← The equation is in the form $ax^2 + bx + c = 0$ so solving using the quadratic formula. $a = 10$, $b = 6$, $c = -52$

$x = 2$, $x = -2.6$ ← The first solution is the x-coordinate of point A. The second solution is the x-coordinate of point B

$y = 3(-2.6) + 1$ ← Substituting -2.6 for x and 1 for p in the equation $y = 3x + p$ finds the y-coordinate of point B

Answer (-2.6 , -6.8)

Turn over for the next question

8

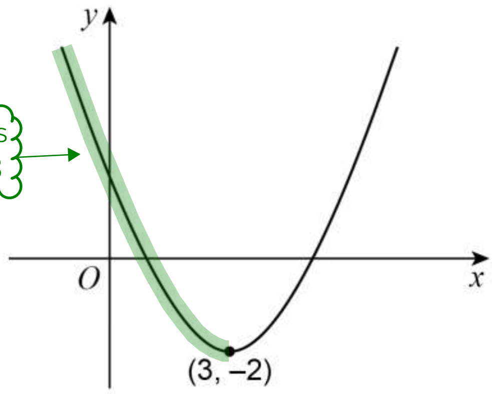
Do not write outside the box

28 Here is a sketch of a quadratic curve.

The turning point is (3, –2)

Not drawn accurately

The gradient of the graph for this section, not including when x is 3



Circle the correct statement about the gradient of the curve for $x < 3$

[1 mark]

gradient is positive	gradient is negative
gradient is zero	gradient could be any value

The line is sloping downwards

END OF QUESTIONS

1