

Edexcel IGCSE 4MA1

Paper 2FR (Foundation Tier) – November 2024

100 marks · 2 hours · Calculator allowed

by Sir Faraz Hassan · IGCSE / GCSE Maths Specialist

Full original worked solutions and mark schemes for every question on this paper.

Original worked solutions for Edexcel International GCSE Mathematics A (4MA1), Paper 2FR (Foundation Tier), November 2024 – 100 marks, 2 hours, calculator allowed. The questions have been reworded; all numerical values match the original paper. The official question paper and mark scheme are published by Pearson Edexcel. This resource reproduces neither the exam paper nor the official mark scheme.

Both are PDF files hosted by Pearson: [official question paper \(PDF\)](#) and [official mark scheme \(PDF\)](#).

Practice Questions

Try each question on paper first. Full worked solutions and mark schemes follow in the next section.

1. (a) Arrange these five numbers in order of size, smallest first.

122 5 150 71 39 [1 mark]



- (b) Arrange these five decimals in order of size, smallest first.

0.7 0.074 3.77 0.37 0.13 [1 mark]

- (c) Write the number five thousand and eighty four in figures. [1 mark]

- (d) Write down what the digit 3 is worth in the number 1324 [1 mark]

(a)

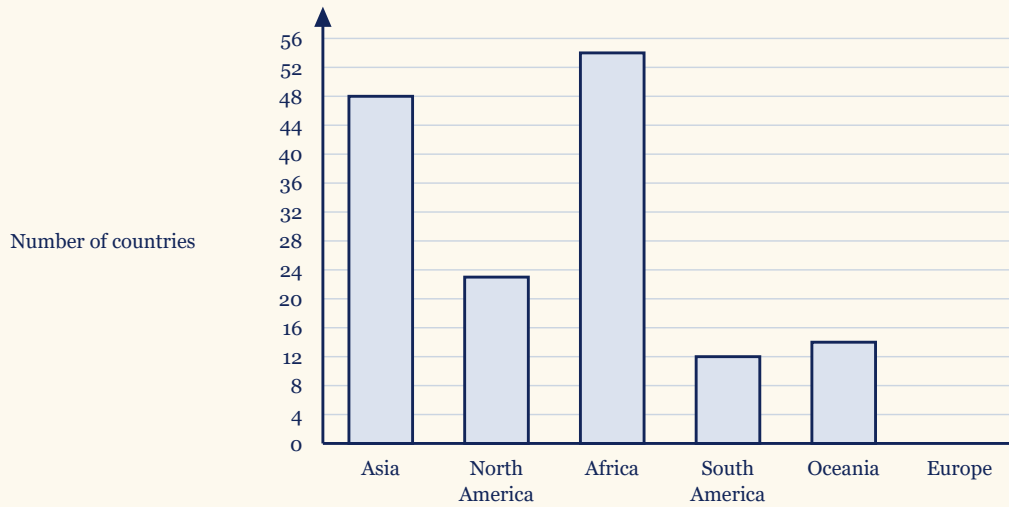
(b)

(c)

(d)

[Total 4 marks]

2. An atlas records the total number of countries in each continent.
The bar chart shows this information for five of the continents.



Europe has a total of 44 countries.

- (a) Complete the bar chart by drawing the bar for Europe. *[1 mark]*
- (b) Write down the name of the continent that has 23 countries. *[1 mark]*
- (c) One continent has 4 times as many countries as South America.
Write down the name of this continent. *[1 mark]*
- (d) Work out the total number of countries in Africa and Oceania
altogether. *[1 mark]*

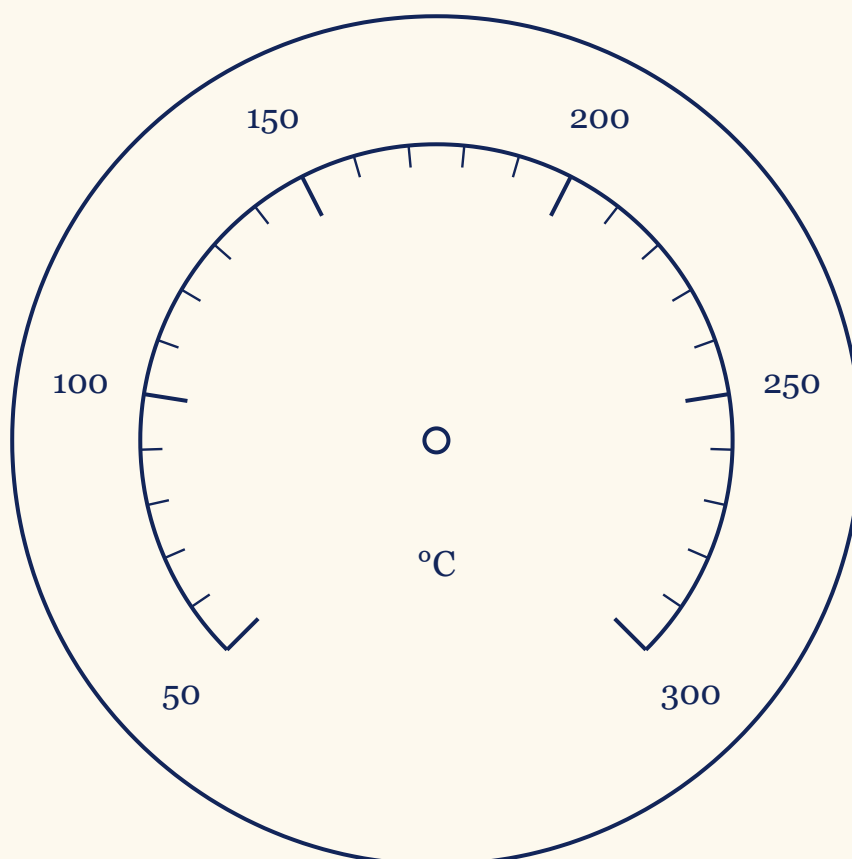
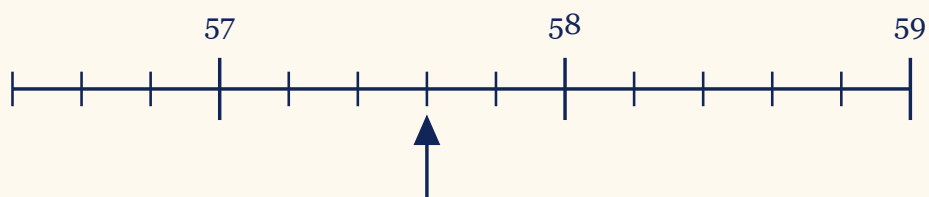
(b)

(c)

(d)

[Total 4 marks]

3. Part of a number line is shown below.



- (a) Write down the number marked by the arrow. [1 mark]
- (b) The diagram below shows the temperature dial on a pottery kiln. On this dial, draw an arrow to show a temperature of 240°C [1 mark]
- (c) Write the number 0.786 correct to 2 decimal places. [1 mark]

(a)

(c)

[Total 3 marks]

4. The diagram below shows a quadrilateral.

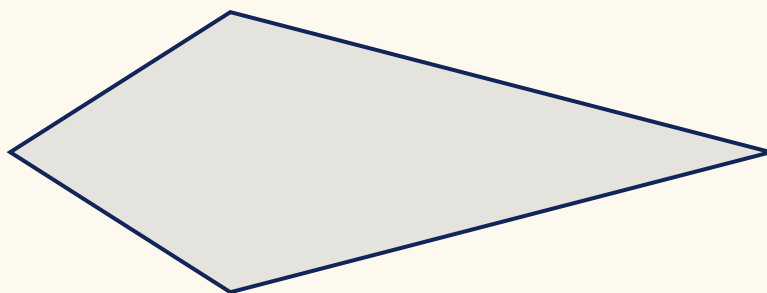
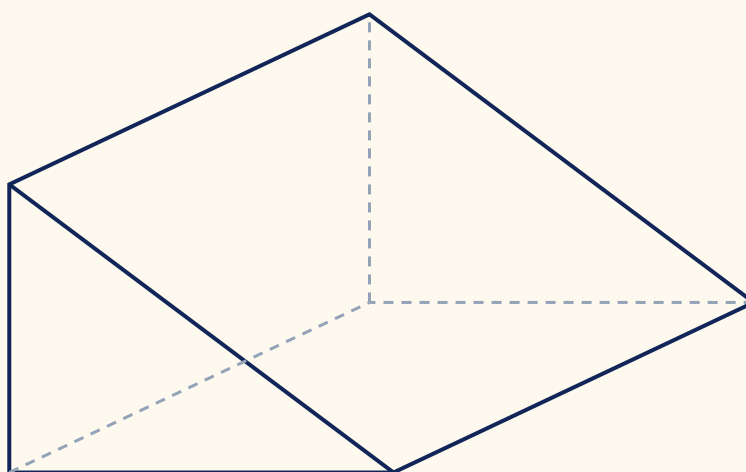


Diagram NOT
accurately drawn



- (a) Write down the mathematical name of this type of quadrilateral. *[1 mark]*

The second diagram shows a solid 3-D shape.

- (b) (i) Write down the mathematical name of this 3-D shape.
[1 mark]
(ii) Write down the number of edges this shape has. *[1 mark]*

- (a)
(b)(i)
(b)(ii)

[Total 3 marks]

5. Amira has 5 litres of orange squash in a large jug and a tray of empty glasses.



She fills as many glasses as possible with squash from the jug.

She puts 280 millilitres of squash into each glass.

Work out how many glasses Amira completely fills. [3 marks]

.....
[Total 3 marks]

6. (a) Work out the value of 3.4^2

[1 mark]

(b) Work out the cube root of 373 248

[1 mark]

(c) Write $7 \times 7 \times 7 \times 7 \times 7 \div 7$ as a single power of 7

[1 mark]

(d) Put one set of brackets into each calculation below to make the answer correct.

(i) $5 + 3 \times 2 = 16$

[1 mark]

(ii) $10 - 8 - 10 - 6 \div 2 = 0$ [1 mark]



(a)

(b)

(c)

[Total 5 marks]

7. The first five terms of a number sequence are shown below.



−3 5 13 21 29

(a) (i) Write down the next term of the sequence.

[1 mark]

(ii) Explain how you found your answer. [1 mark]

(b) Explain why 326 cannot be a term of this sequence. [1 mark]

(a)(i)

(a)(ii)

(b)

[Total 3 marks]

8. Anish buys some screws and some washers.



Each box of screws costs £2.60

Each pack of washers costs £3.94

Anish buys 5 boxes of screws and 4 packs of washers.

Anish pays with a £50 note.

Work out how much change Anish should get. [3 marks]

£

[Total 3 marks]

9. (a) Write $c \times c \times c$ in its simplest form. [1 mark]



(b) Simplify $12d \times 3e$ [1 mark]

(c) Solve the equation $\frac{k}{4} = 7$ [1 mark]

(d) Solve the equation $2g - 3 = 6$ [2 marks]

(e) Expand the brackets $x(x - 4)$ [1 mark]

$$P = 4y^2 + w$$

(f) Work out the value of P when $y = -3$ and $w = 2$ [2 marks]

(a)

(b)

(c) $k =$

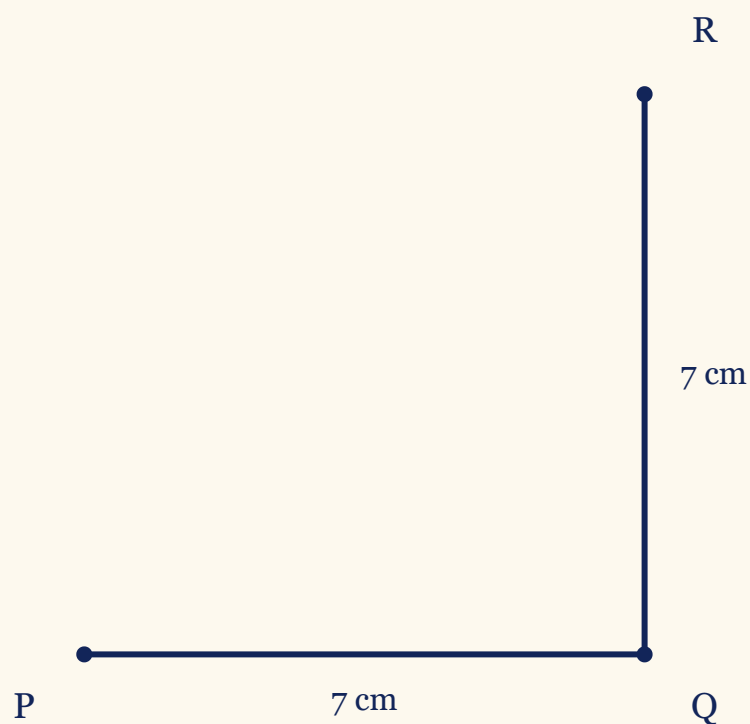
(d) $g =$

(e)

(f) $P =$

[Total 8 marks]

- 10.** Using only a ruler and a pair of compasses, construct a square of side 7 cm. Two of the four sides, PQ and QR , have already been drawn for you. You must leave in all your construction lines. [2 marks]



[Total 2 marks]

- 11.** A tea room sells 4 different types of tart.

cherry (C), fig (F), lemon (L), maple (M)

Amara is going to choose 2 different types of tart.

(a) Write down all the possible combinations she can choose. [2 marks]

	Peach	Berry	Ginger	Total
Saturday		11	28	
Sunday		20	13	49
Total	48	31	41	

The two-way table gives some information about the flavours of iced tea sold by the tea room on Saturday and on Sunday.

(b) Complete the two-way table. [2 marks]

Amara asks 100 visitors whether they prefer tarts or iced tea.

33 of the visitors prefer tarts.

One of the 100 visitors is chosen at random.

(c) Find the probability that this visitor does not prefer tarts. [1 mark]

(a)

(a)

(a)

(c)

[Total 5 marks]

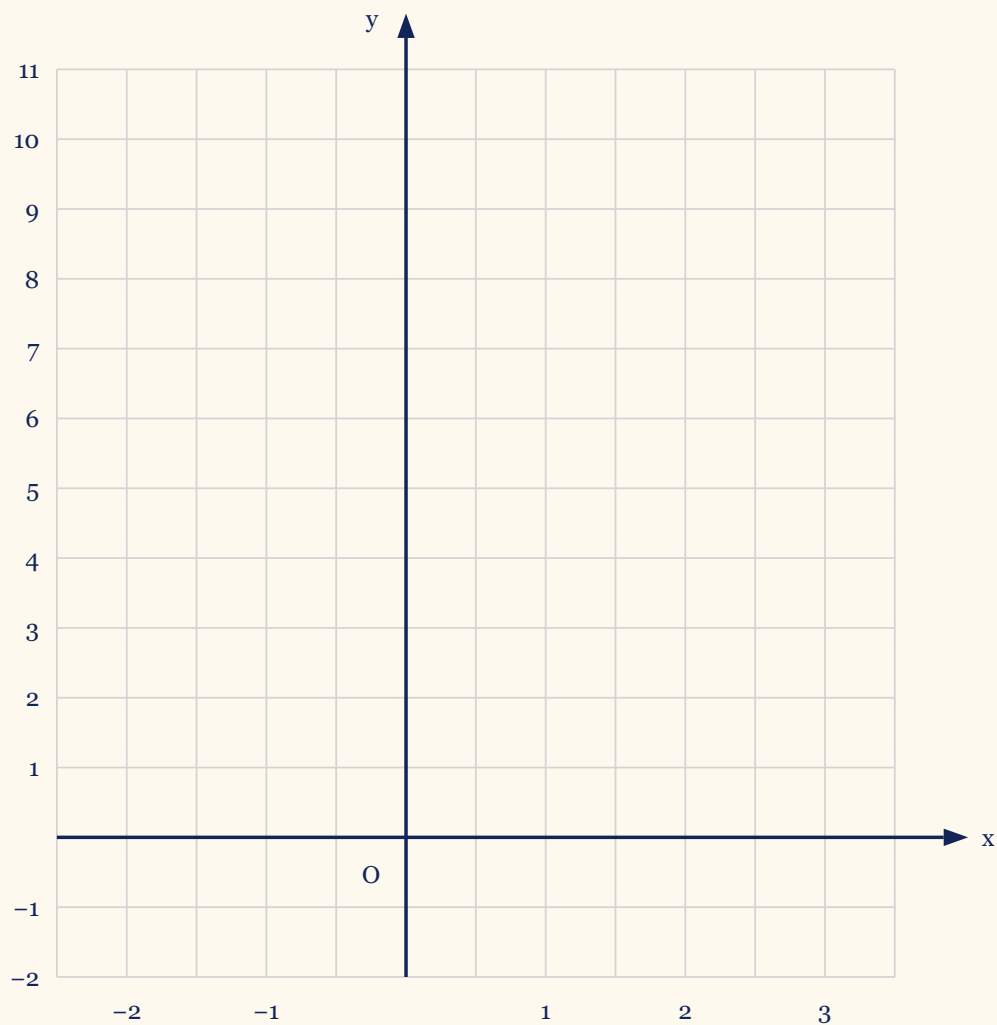
- 12.** A regular polygon has an exterior angle of 15° at each of its vertices.

Work out how many sides this polygon has. [2 marks]

.....

[Total 2 marks]

- 13.** On the grid below, draw the graph of $y = 5 - 2x$ for all values of x from -2 to 3 . [3 marks]



[Total 3 marks]

- 14.** A charity book sale raises 1200 euros. Shalini, Marta and Lucas share the 1200 euros.



Shalini gets $\frac{1}{5}$ of the 1200 euros.

Marta gets 42% of the 1200 euros.

Lucas gets the rest of the 1200 euros.

Given that

the amount of money Shalini gets : the amount of money Lucas gets

= 1 : n

work out the value of n [4 marks]

$n =$

[Total 4 marks]

- 15.** The table gives information about the number of plums in each of 30 punnets.



Number of plums	Frequency
11	7
12	8
13	7
14	5
15	1
16	2

- (a) Write down the mode of the number of plums in a punnet. *[1 mark]*
- (b) Work out the mean number of plums in a punnet. *[3 marks]*

(a)

(b)

[Total 4 marks]

- 16.** Glass jars are made at a bottling plant.



On Wednesday, 375 jars per hour were made at the plant.

On Wednesday, jars were made at the plant for 8 hours.

On Thursday, 20% more jars were made than on Wednesday.

On Thursday, 300 jars per hour were made at the plant.

Work out for how many hours the plant made jars on Thursday. *[4 marks]*

..... hours

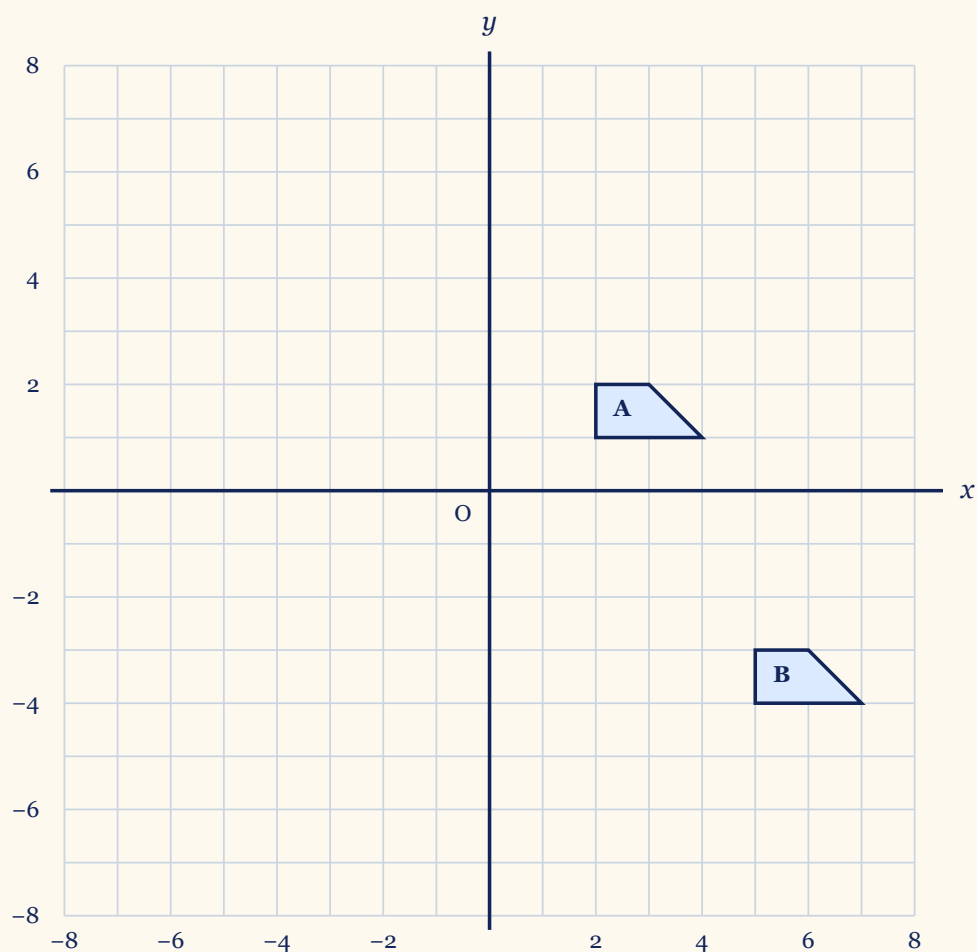
[Total 4 marks]

- 17.** Express 1400 as a product of powers of its prime factors.
Show your working clearly. *[3 marks]*



.....
[Total 3 marks]

18. The grid shows two shapes, A and B .



(a) Describe fully the single transformation that maps shape A onto shape B . [2 marks]

(b) On the same grid, rotate shape A through 180° about the point $(-1, 0)$.

Label your new shape C . [2 marks]

(a)

[Total 4 marks]

- 19.** Four numbers are written below in ascending order of size.



x x y 15

In this list x and y are integers.

The four numbers have
a median of 12.5
a range of 4

Work out the value of x and the value of y . [2 marks]

$x =$

$y =$

[Total 2 marks]

20. $\mathcal{E} = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$

$A = \{\text{factors of } 6\}$

$B = \{\text{prime numbers}\}$



(a) List the members of the set

(i) $A \cup B$

[1 mark]

(ii) A' [1 mark]

Anjali claims that $A \cap B = \emptyset$

Anjali is wrong.

(b) Explain why. [1 mark]

C is a set with 4 members such that

the set $A \cap C$ has 2 members

the set $B \cap C$ has 2 members

Set $A \cap C$ and set $B \cap C$ have no members in common.

(c) List the 4 members of set C [2 marks]

(a)(i)

(a)(ii)

(b)

(c)

[Total 5 marks]

- 21.** The diagram shows the design for a pendant, which will be made using wire.



The design is a circle inside a square $ABCD$

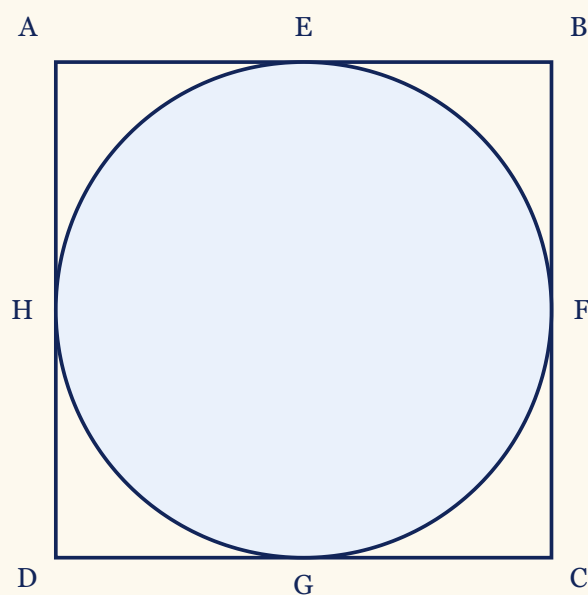


Diagram NOT
accurately drawn

The circle touches the square at the points E , F , G and H

The area of the square is 81 cm^2

Calculate the total length of wire that will be needed to make the square and the circle.

Give your answer correct to 3 significant figures. [4 marks]

..... cm

[Total 4 marks]

22. (a) Solve $\frac{2f}{3} = 4f - 17$



You must show clear algebraic working. [3 marks]

(b) Simplify $(e + 12)^0$ where $e > 0$ [1 mark]

(c) Simplify fully $\frac{12a^4h^6}{4ah^2}$ [2 marks]

(d) Factorise fully $20x^5y + 12x^3y^4$ [2 marks]

(a) $f =$

(b)

(c)

(d)

[Total 8 marks]

23. $\frac{3^{-2} \times 3^5}{3^{10}} = 3^n$



Work out the value of n . [2 marks]

$n =$

[Total 2 marks]

24. In a clearance sale at an electrical store, all normal prices are reduced by 17%



The sale price of a washing machine is 6225 rupees.

Work out the normal price of the washing machine. [3 marks]

..... rupees

[Total 3 marks]

25. (a) Change 6.04×10^5 into an ordinary number. [1 mark]



(b) Express 0.000 07 in standard form. [1 mark]

(c) Work out $\frac{7.6 \times 10^{10}}{4 \times 10^5 - 2 \times 10^4}$

Give your answer in standard form. [2 marks]

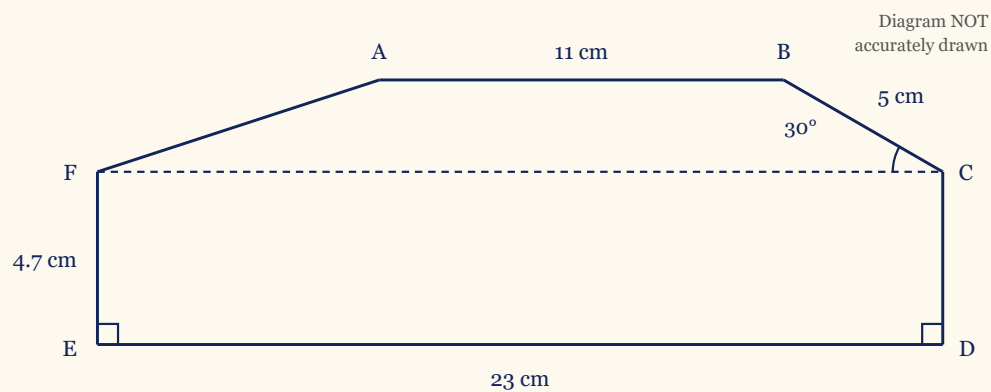
(a)

(b)

(c)

[Total 4 marks]

26. The diagram shows the hexagon $ABCDEF$.



Angle $BCF = 30^\circ$

AB , FC and ED are parallel.

Work out the total area of $ABCDEF$.

You must show all of your working. [5 marks]

..... cm^2

[Total 5 marks]

Worked Solutions & Mark Schemes

Every mark (M for method, A for accuracy) is shown, just like a real examiner.

Question 1 - Exam Solution

Understanding the Question

Given

Five whole numbers: 122, 5, 150, 71, 39

Five decimals:

0.7, 0.074, 3.77, 0.37, 0.13

The number five thousand and eighty four, written in words.

The number 1324, with attention on its digit 3.

Find

(a) the five numbers in order, smallest first (b) the five decimals in order, smallest first (c) five thousand and eighty four written in figures (d) what the 3 in 1324 is worth

Plan the Solution

- All four parts are place value, so read every number column by column rather than at a glance.
- (a) Count the digits first: a number with fewer digits is smaller. Only inside a group of the same length do you compare digits from the left.
- (b) Give every decimal the same number of decimal places, then the comparison becomes a whole-number one.
- (c) Write the thousands, hundreds, tens and units columns in turn, using 0 for any column the words do not mention.
- (d) Find which column the 3 stands in, then multiply the digit by that column's place value.

Worked Solution [4 marks]

Rule - Place value: a digit is worth its face value multiplied by the column it stands in (units 1, tens 10, hundreds 100, thousands 1000), and numbers are compared by their highest column first.

Step 1: (a) sort the whole numbers by length, then by leading digit

$$5 < 39 < 71 < 122 < 150$$

(Reason: 5 has one digit, 39 and 71 have two, and 122 and 150 have three, so the one-digit number is smallest and the three-digit numbers are largest. Inside each group compare from the left: 3 tens is less than 7 tens, and 122 and 150 share a hundreds digit, so the tens decide it because 2 is less than 5.)

Step 2: (b) give every decimal the same number of decimal places

$$0.700, 0.074, 3.770, 0.370, 0.130$$

$$74 < 130 < 370 < 700 < 3770$$

$$0.074 < 0.13 < 0.37 < 0.7 < 3.77$$

(Reason: Filling the short ones with trailing zeros changes nothing, because a zero on the end of a decimal adds no value. With three decimal places each, the five decimals are 700, 74, 3770, 370 and 130 thousandths, and ordering whole numbers of thousandths is easy. The commonest slip is reading 0.7 as smaller than 0.074 because it has fewer digits.)

Step 3: (c) build the number one column at a time

$$5000 + 84 = 5084$$

(Reason: Five thousand is a 5 in the thousands column, and eighty four is 8 tens and 4 units. The words never mention hundreds, so that column takes a 0 to hold the 5 in the thousands place. Leaving it out would give 584, a different number.)

Step 4: (d) find the column the digit 3 stands in

$$1324 = 1000 + 300 + 20 + 4$$

$$3 \times 100 = 300$$

(Reason: Reading 1324 column by column gives 1 thousand, 3 hundreds, 2 tens and 4 units, so the 3 stands in the hundreds column. Its worth is the digit multiplied by that column's place value. The mark scheme accepts either the words or the number.)

(a) 5, 39, 71, 122, 150

(b) 0.074, 0.13, 0.37, 0.7, 3.77

(c) 5084

(d) 3 hundreds, that is 300

Verification

- ✓ **Check 1:** Read both ordered lists backwards. They must run largest first and still hold all five of the given values, none lost and none invented: 150, 122, 71, 39, 5 and 3.77, 0.7, 0.37, 0.13, 0.074. Five values in, five values out, in the opposite order
- ✓ **Check 2:** Order the decimals a second way, without lining up any decimal points. Multiply every one by 1000 to get 700, 74, 3770, 370, 130, order those whole numbers, then

divide back by 1000. 0.074, 0.13, 0.37, 0.7, 3.77

- ✓ **Check 3:** Read the answer to (c) back out in words, column by column: 5 thousands, 0 hundreds, 8 tens, 4 units. 5084 reads as five thousand and eighty four
- ✓ **Check 4:** Take the value of the 3 away from 1324 and look at what is left:
 $1324 - 300 = 1024$. The hundreds column of 1024 is now empty. Only the hundreds column emptied, so the 3 was worth 300

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a) 5, 39, 71, 122, 150	B1	All five numbers in the correct order, smallest first.	✓
(b) 0.074, 0.13, 0.37, 0.7, 3.77	B1	All five decimals in the correct order, smallest first.	✓
(c) 5084	B1	The four-digit number, with the 0 in the hundreds column.	✓
(d) 3 hundreds	B1	Accept 300 or the word hundreds on its own.	✓

Full marks: 4/4

Question 2 - Exam Solution

Understanding the Question

Given

A bar chart of the number of countries in five continents: Asia 48, North America 23, Africa 54, South America 12 and Oceania 14.

Europe has 44 countries, and its bar has not been drawn.

The vertical scale runs from 0 to 56 and is labelled every 4 countries.

Find

(a) The Europe bar, drawn to the right height. (b) The continent whose bar reads 23. (c) The continent whose total is 4 times the South America total. (d) The Africa total added to the Oceania total.

Plan the Solution

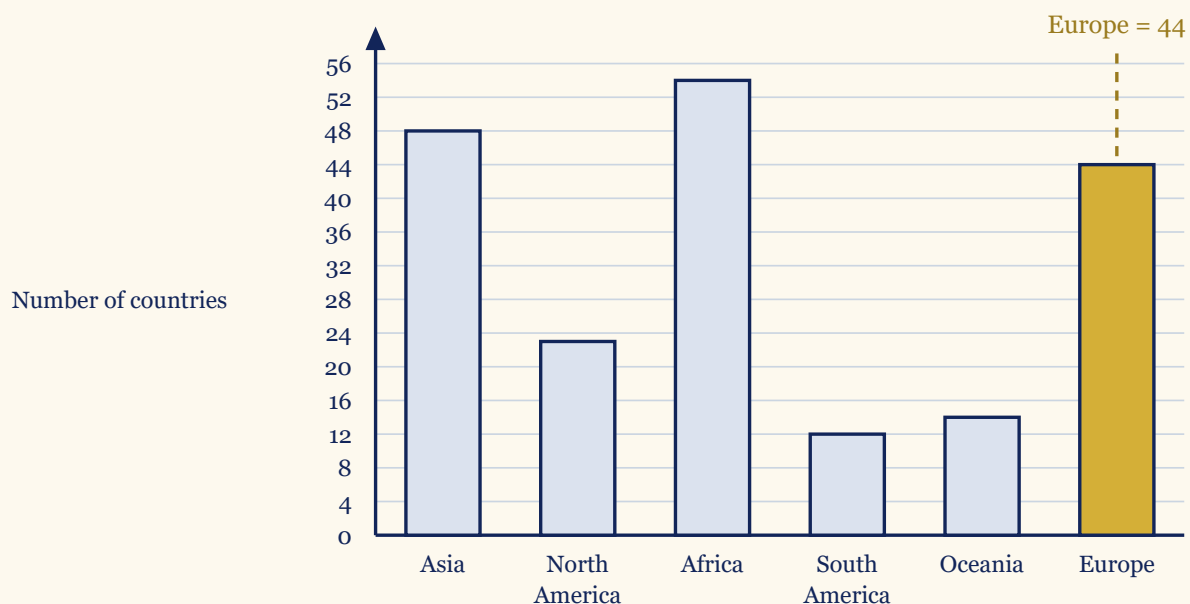
- Read every bar against the vertical scale, remembering that one gridline to the next is 4 countries, not 1.
- For (a), find 44 on the scale and draw a bar of the same width as the others up to that line.
- For (b), look for the bar that stops just short of the line marked 24.
- For (c), work out 4×12 first, then find the bar of that height.
- For (d), add the two totals that have been read off.

Worked Solution [4 marks]

Rule - Reading a bar chart: the height of a bar against the vertical scale is the value it stands for, and a value between two gridlines is found by counting on from the gridline below it.

Step 1: draw the bar for Europe (part (a))

$$11 \times 4 = 44$$



(Reason: The scale rises in steps of 4, so 44 is eleven whole steps above zero and is itself a labelled line. Draw a bar in the Europe position, the same width as the others, with its top level with that line.)

Step 2: find the bar that reads 23 (part (b))

$$23 = 20 + 3$$

(Reason: A bar at 23 sits three above the line marked 20 and just below the line marked 24. Only the second bar does that, and it is North America.)

Step 3: find the continent with 4 times the South America total (part (c))

$$4 \times 12 = 48$$

(Reason: South America reads 12, so the continent being asked for reads 48. The only bar level with the line marked 48 is Asia.)

Step 4: add Africa and Oceania (part (d))

$$54 + 14 = 68$$

(Reason: Africa is the tallest bar and reads 54. Oceania is the fifth bar and reads 14. The word altogether means the two totals are added.)

(a) Europe bar drawn to a height of 44

(b) North America

(c) Asia

(d) 68

Verification

- ✓ **Check 1:** Count the gridlines for part (a). The scale goes up in 4s, and $11 \times 4 = 44$. The Europe bar is level with the eleventh gridline above zero, the one already labelled 44.
- ✓ **Check 2:** Do part (c) the other way round, by dividing instead of multiplying: $\frac{48}{12} = 4$.
Asia has exactly 4 times as many countries as South America, which is what part (c) asked for.
- ✓ **Check 3:** Do part (d) from the whole chart. All six continents come to $48 + 23 + 54 + 12 + 14 + 44 = 195$, and the four that part (d) does not use come to $48 + 23 + 12 + 44 = 127$, so $195 - 127 = 68$. Africa and Oceania together come to 68, reached without adding those two bars directly.
- ✓ **Check 4:** Make sure part (b) has only one answer by listing the other five totals: 48, 54, 12, 14 and 44. None of them is 23, so North America is the only continent that fits.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a) A bar drawn in the Europe position of height 44	B1	The bar must reach the line marked 44 and be about the same width as the other bars.	✓
(b) North America	B1	The name of the continent, however it is spelled out.	✓

Step	Mark	Description	Got it?
(c) Asia	B1	The name only. Working such as $4 \times 12 = 48$ earns nothing on its own.	✓
(d) 68	B1	The answer 68. A misread of either bar loses the mark, as there is no method mark on this part.	✓

Full marks: 4/4

Question 3 - Exam Solution

Understanding the Question

Given

Part of a number line on which 57, 58 and 59 are labelled, each labelled gap being cut into 5 equal parts by short marks.

A kiln dial labelled 50, 100, 150, 200, 250, 300, again with 5 equal parts in each labelled gap.

The number 0.786.

Find

(a) the number the arrow on the number line points to (b) where on the dial an arrow showing 240°C must be drawn (c) 0.786 written correct to 2 decimal places

Plan the Solution

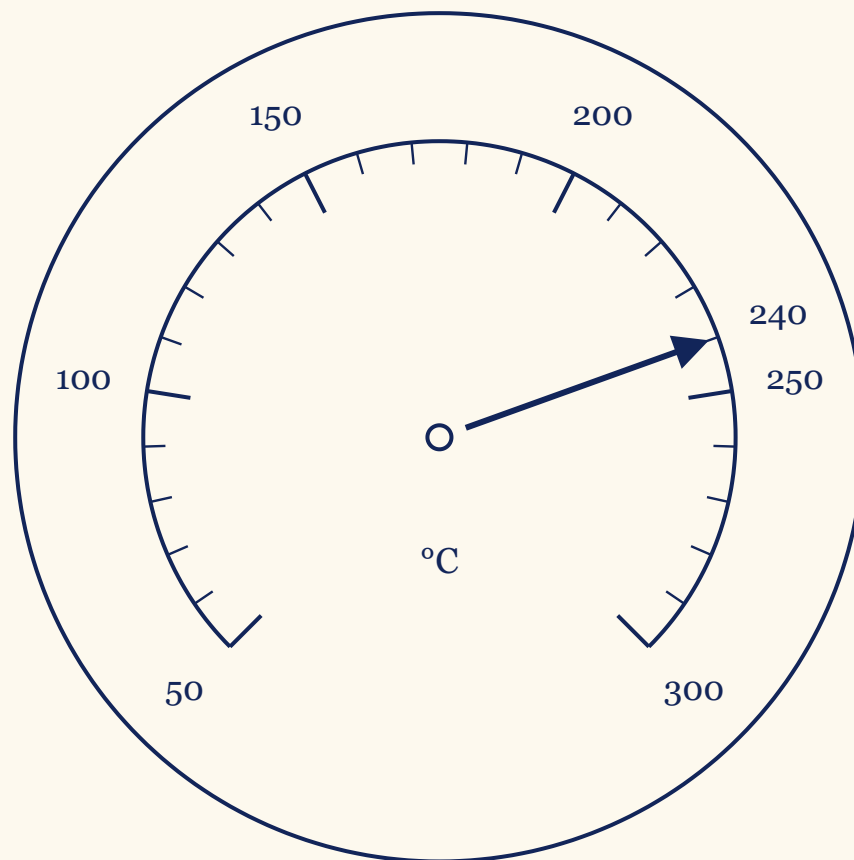
- Both diagrams are scales, so treat them the same way: never read a scale until you know what one small division is worth.
- Find the value of one small division by dividing a labelled gap by the number of equal parts it is cut into, then count divisions on from the nearest labelled mark.
- For the rounding, look at the digit in the third decimal place of 0.786 and decide which of the two neighbouring hundredths it sits nearer to.

Worked Solution [3 marks]

Rule - Reading a scale: one small division = the gap between two labelled marks divided by the number of equal parts between them. Rounding to 2 decimal places keeps 2 digits after the point, and the next digit decides whether the last one goes up.

Step 1: Work out one small division on the number line

$$\frac{58 - 57}{5} = \frac{1}{5} = 0.2$$



(Reason: (Reason: the gap from 57 to 58 is worth 1 and it is cut into 5 equal parts, so each short mark is worth 0.2.))

Step 2: Count on from the 57 mark

$$57 + 3 \times 0.2 = 57.6$$

(Reason: (Reason: the arrow stands at the third short mark to the right of 57, so add three small divisions to 57.))

Step 3: Work out one small division on the kiln dial

$$\frac{250 - 200}{5} = \frac{50}{5} = 10$$

(Reason: (Reason: the dial is labelled every 50 degrees and each labelled gap carries 5 short marks, so one small division is 10 degrees.))

Step 4: Count on from the 200 mark to place the arrow

$$200 + 4 \times 10 = 240$$

(Reason: (Reason: 240 is four small divisions past 200, so the arrow is drawn from the centre out to that mark.))

Step 5: Round 0.786 correct to 2 decimal places

$$0.786 \approx 0.79$$

(Reason: (Reason: keeping 2 decimal places means choosing between 0.78 and 0.79. The next digit is 6, which is 5 or more, so the hundredths digit goes up from 8 to 9.))

(a) 57.6

(b) an arrow drawn on the dial pointing at 240

(c) 0.79

Verification

- ✓ **Check 1:** Read the number line from the other end. The arrow is 2 small divisions to the left of 58, and each is worth 0.2. $58 - 2 \times 0.2 = 57.6$
- ✓ **Check 2:** Read the dial from the other end. Counting back from 250, one small division is worth 10 degrees. $250 - 10 = 240$, so the arrow sits one short mark before the 250 label.
- ✓ **Check 3:** Instead of a rounding rule, measure the distance from 0.786 to each of the two hundredths on either side of it. $0.786 - 0.78 = 0.006$ but $0.79 - 0.786 = 0.004$, so 0.79 is the nearer of the two.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a) Reads the number line and gives 57.6	B1	cao. 57.6 only. 57.3 scores nothing - it comes from treating a short mark as 0.1 instead of 0.2.	✓
(b) Draws an arrow on the dial pointing at 240	B1	Arrow pointing at 240, that is at the fourth short mark after 200. The mark is for the drawing, so there is no answer line for this part.	✓
(c) Gives 0.79	B1	cao. 0.79 only. 0.78 scores nothing - it comes from cutting the number short rather than rounding it.	✓

Full marks: 3/3

Question 4 - Exam Solution

Understanding the Question

Given

A quadrilateral whose two shorter sides meet at one vertex and whose two longer sides meet at the opposite vertex

A solid with a triangular face at the front and an identical triangular face behind it

Find

the mathematical name of the quadrilateral the mathematical name of the 3-D shape the number of edges the 3-D shape has

Plan the Solution

- Compare the four sides of the quadrilateral: are the equal sides next to each other, or opposite each other?
- Count the lines of symmetry, because that is what tells a kite apart from a rhombus.
- Look for the face that repeats all the way through the solid, then name the solid from the shape of that face.
- Count the edges of the solid in three groups: the front face, the back face, and the edges that join the two faces.

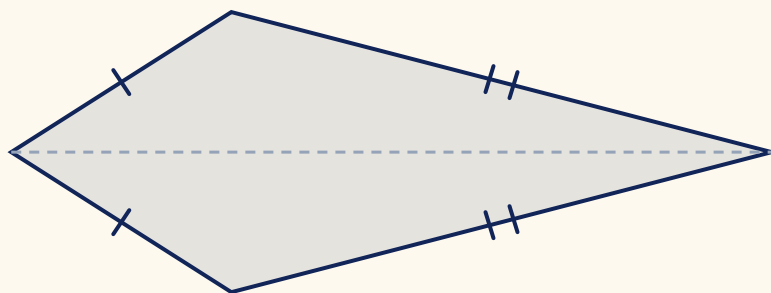
Worked Solution [3 marks]

A kite has two pairs of equal adjacent sides and exactly one line of symmetry. A prism has the same cross-section from one end to the other, and a prism whose cross-section has n sides has $3n$ edges.

Step 1: compare the sides and the symmetry of the quadrilateral

2 pairs of equal adjacent sides

1 line of symmetry



(Reason: The two shorter sides meet at the left-hand vertex and the two longer sides meet at the right-hand vertex, so the equal sides are next to each other and not opposite each other. Folding along the long diagonal maps each short side onto the other one, and that diagonal is the only fold that works. A rhombus would need all four sides equal and two lines of symmetry, and a parallelogram would need its equal sides parallel, so the quadrilateral is a kite.)

Step 2: look for the face that repeats through the solid

2 triangles + 3 rectangles = 5 faces

(Reason: Cutting the solid anywhere between the two ends gives the same triangle every time, so the solid is a prism. The cross-section is a triangle, so it is a triangular prism.)

Step 3: count the edges in three groups

$3 + 3 + 3 = 9$

(Reason: There are three edges round the triangle at the front, three round the identical triangle at the back, and three more joining the two triangles, one at each corner. The dashed lines in the diagram are edges as well: they are the ones hidden behind the solid.)

(a) kite

(b)(i) triangular prism

(b)(ii) 9 edges

Verification

- ✓ **Check 1:** A prism whose cross-section has n sides has $3n$ edges. The cross-section here is a triangle, so $n = 3$. $3 \times 3 = 9$
- ✓ **Check 2:** Euler's formula for a solid says faces plus vertices equals edges plus 2. This prism has 5 faces and 6 vertices. $5 + 6 = 9 + 2$
- ✓ **Check 3:** Test the other quadrilateral names against the drawing. A rhombus needs all four sides equal, a parallelogram needs both pairs of opposite sides parallel, and a

trapezium needs one pair of parallel sides. This quadrilateral has 0 pairs of parallel sides and two different side lengths. No other name fits, so the quadrilateral is a kite.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a) Names the type of quadrilateral	B1	kite	✓
(b)(i) Names the 3-D shape	B1	prism, accept triangular prism	✓
(b)(ii) States how many edges the shape has	B1	9	✓

Full marks: 3/3

Question 5 - Exam Solution

Understanding the Question

Given

The jug holds 5 litres of squash.
Every glass is filled with 280 millilitres of squash.
The glasses must be filled completely, so a part-filled glass does not count.

Find

The number of glasses that Amira can fill completely from the jug.

Plan the Solution

- The two amounts are in different units, so change the litres into millilitres first.
- Divide the total amount by the amount that goes into one glass.
- That division does not come out exactly, so keep only the whole-number part: the leftover squash is not enough to fill another glass.

Worked Solution [3 marks]

Rule - Same units first: 1 litre = 1000 millilitres. Then the number of full glasses is $\frac{\text{total millilitres}}{\text{millilitres in one glass}}$, keeping only the whole-number part.

Step 1: Put both amounts into the same unit

$$5 \times 1000 = 5000 \text{ ml}$$

(Reason: The jug is measured in litres and each glass in millilitres, so one of them has to be changed before they can be compared. Millilitres is the easier choice here, because the glass is already measured in them.)

Step 2: Divide the total by the amount in one glass

$$\frac{5000}{280} = \frac{125}{7} = 17\frac{6}{7}$$

(Reason: Dividing counts how many lots of 280 millilitres fit inside 5000 millilitres. A calculator gives $17.857 \dots$, which is the same number written as a decimal.)

Step 3: Keep only the whole glasses

$$17 \times 280 = 4760$$

$$18 \times 280 = 5040$$

(Reason: Seventeen glasses take 4760 millilitres, which the jug can supply. Eighteen glasses would need 5040 millilitres and only 5000 millilitres are there, so the last 240 millilitres are left in the jug. The answer is rounded down, never up.)

17 glasses

Verification

- ✓ **Check 1:** Multiply back: 17 glasses at 280 millilitres each. $17 \times 280 = 4760$ millilitres, which is inside the 5000 millilitres available, with 240 millilitres to spare.
- ✓ **Check 2:** Test one more glass, to be sure the answer is not 18. $18 \times 280 = 5040$ millilitres, which is 40 millilitres more than there is, so the eighteenth glass cannot be filled.
- ✓ **Check 3:** Redo the whole question in litres instead, by converting the glass rather than the jug. 280 millilitres is 0.28 litres, and $\frac{5}{0.28} = 17\frac{6}{7}$ as well, so the whole-number part is still 17.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
$5 \times 1000 = 5000$ or $\frac{280}{1000} = 0.28$	M1	for a correct conversion between millilitres and litres	✓

Step	Mark	Description	Got it?
$\frac{5000}{280}$ or $\frac{5}{0.28}$ or $\frac{125}{7}$ or $17\frac{6}{7}$	M1	for a complete method. Follow through an incorrect conversion, but an attempt to convert must have been made.	✓
17	A1	cao	✓
$17 \times 280 = 4760$ or $17 \times 0.28 = 4.76$	M2	Alternative complete method: building up to the largest multiple of 280 that still fits inside 5000. This scores M2 in place of the two method marks above, and A1 still follows for 17.	✓
Working not required, so a correct answer scores full marks, unless it comes from obviously incorrect working.	Note	A guidance row. It carries no mark of its own and does not add to the total of three.	✓

Full marks: 3/3

Question 6 - Exam Solution

Understanding the Question

Given

- (a) the square 3.4^2
- (b) the cube root of 373 248
- (c) the calculation
 $7 \times 7 \times 7 \times 7 \times 7 \div 7$
- (d) two calculations, each of which needs one set of brackets: $5 + 3 \times 2$ is to come to 16, and $10 - 8 - 10 - 6 \div 2$ is to come to 0

Find

The value of 3.4^2 , the cube root of 373 248, the single power of 7, and where the one set of brackets goes in each calculation in part (d). Five separate answers, one mark each, and a calculator is allowed throughout.

Plan the Solution

- (a) Squaring means multiplying the number by itself, so work out 3.4×3.4 .
- (b) A cube root asks which number, multiplied by itself three times, gives 373 248. Bracket it between 70 and 80 first, then test.

- (c) Count the sevens. Five multiplied together make 7^5 , and dividing by one more seven lowers the index by 1.
- (d) Work each calculation out exactly as it is printed. Comparing that value with the target shows which operation has to be forced to happen first, and the brackets go round that operation.

Worked Solution [5 marks]

Brackets are worked out first, then powers and roots, then multiplication and division, and addition and subtraction last. Powers of the same base divide by subtracting the indices: $7^5 \div 7^1 = 7^{5-1}$.

Step 1 (part a): multiply 3.4 by itself

$$3.4^2 = 3.4 \times 3.4 = 11.56$$

(Reason: (Reason: the small 2 counts how many times the number appears in the multiplication, so 3.4^2 is 3.4 written down twice and multiplied.))

Step 2 (part b): find the number whose cube is 373 248

$$70^3 = 343\,000$$

$$72^3 = 72 \times 72 \times 72$$

$$72 \times 72 = 5\,184$$

$$5\,184 \times 72 = 373\,248$$

(Reason: (Reason: 70^3 is a little under the target and 80^3 is far over it, so the root is in the low seventies. On a calculator the cube root key gives 72 straight away, but the cube is worth writing out as proof.))

Step 3 (part c): count the sevens

$$7 \times 7 \times 7 \times 7 \times 7 = 7^5$$

$$7^5 \div 7 = 7^{5-1}$$

$$7^{5-1} = 7^4$$

(Reason: (Reason: five sevens are multiplied together, and dividing cancels one of them, leaving four. In index form that is 5 take away 1.))

Step 4 (part d(i)): force the addition to happen first

$$5 + 3 \times 2 = 11$$

$$(5 + 3) \times 2 = 8 \times 2 = 16$$

(Reason: (Reason: as printed, the multiplication is done before the addition and the calculation comes to 11. The target 16 is 8 doubled, and 8 is $5 + 3$, so the brackets go round the addition.))

Step 5 (part d(ii)): halve the $10 - 6$ instead

$$10 - 8 - 10 - 6 \div 2 = 10 - 8 - 10 - 3 = -11$$

$$10 - 8 - (10 - 6) \div 2 = 10 - 8 - 4 \div 2$$

$$10 - 8 - 4 \div 2 = 10 - 8 - 2 = 0$$

(Reason: (Reason: as printed, only the 6 is divided by 2 and the calculation comes to -11 . Bracketing $10 - 6$ makes 4 the thing that is halved, so 2 is taken from $10 - 8$ and nothing is left.))

$$(a) 11.56$$

$$(b) 72$$

$$(c) 7^4$$

$$(d)(i) (5 + 3) \times 2 = 16$$

$$(d)(ii) 10 - 8 - (10 - 6) \div 2 = 0$$

Verification

- ✓ **Check 1 (part a):** Take the decimal point out and square 34 instead: $34 \times 34 = 1156$. Each factor carries one decimal place, so the answer carries two. Putting the point back two places gives 11.56, which is the value found in step 1.
- ✓ **Check 2 (part b):** Split the target into prime factors: $2^9 \times 3^6 = 512 \times 729 = 373\,248$. A cube root takes a third of each index. $2^3 \times 3^2 = 8 \times 9 = 72$, agreeing with step 2, and every index divides by 3 exactly, so the cube root is a whole number.
- ✓ **Check 3 (part c):** Work the whole calculation out as ordinary numbers: $7 \times 7 \times 7 \times 7 \times 7 = 16\,807$, and then $16\,807 \div 7 = 2\,401$. $7^4 = 2\,401$, the same number, so the single power is right.
- ✓ **Check 4 (part d(i)):** Try the only other place the brackets could go: $5 + (3 \times 2) = 11$, which is what the calculation already came to. Bracketing the multiplication changes nothing, so $(5 + 3) \times 2$ is the only placement that reaches 16.
- ✓ **Check 5 (part d(ii)):** Try other placements: $(10 - 8) - 10 - 6 \div 2 = -11$, $10 - (8 - 10) - 6 \div 2 = 9$ and $10 - 8 - (10 - 6 \div 2) = -5$. None of them is 0, so the brackets must go round $10 - 6$.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a)	B1	11.56. Accept an exact equivalent, for example $\frac{289}{25}$ or $11\frac{14}{25}$.	✓

Step	Mark	Description	Got it?
(b)	B1	72. Working is not required, so the correct answer alone scores the mark.	✓
(c)	B1	7^4 . The answer must be a single power of 7, so 2 401 on its own does not score.	✓
(d)(i)	B1	$(5 + 3) \times 2 = 16$	✓
(d)(ii)	B1	$10 - 8 - (10 - 6) \div 2 = 0$	✓

Full marks: 5/5

Question 7 - Exam Solution

Understanding the Question

Given

A number sequence beginning $-3, 5, 13, 21, 29$

The same amount is added to get from each term to the next, so this is an arithmetic sequence.

Find

(a)(i) the term that comes after 29 (a)(ii) an explanation of how that term was found (b) a reason why 326 can never appear in the sequence

Plan the Solution

- Subtract each term from the one after it, to find the common difference.
- Add that difference to the last term given, to get the next term.
- Turn the pattern into an n th term rule, so that part (b) can be settled by calculation rather than by guessing.
- Test 326 against the rule, then back the answer up with an odd and even argument.

Worked Solution [3 marks]

Rule - Arithmetic sequence: the terms go up by a fixed common difference d , so the n th term is $a + (n - 1)d$, where a is the first term.

Step 1: Find the common difference

$$5 - (-3) = 8$$

$$13 - 5 = 8$$

$$21 - 13 = 8$$

$$29 - 21 = 8$$

(Reason: All four gaps are the same, so the sequence is arithmetic with common difference $d = 8$. Subtracting a negative first term is what makes the first gap 8 and not 2.)

Step 2: Add the common difference to the last term given

$$29 + 8 = 37$$

(Reason: Part (a)(i) asks only for the next term, so one addition is enough: the sixth term is 37.)

Step 3: Say what the rule is, in words

$$\text{next term} = \text{previous term} + 8$$

(Reason: Part (a)(ii) asks how the answer was found. Every term is 8 more than the one before it, so the answer is simply that 8 was added.)

Step 4: Build the n th term rule

$$a = -3 \quad \text{and} \quad d = 8$$

$$a + (n - 1)d = -3 + (n - 1) \times 8 = 8n - 11$$

$$\text{check } n = 6 : \quad 8 \times 6 - 11 = 37$$

(Reason: The rule is checked against a term that is already known before it is trusted. It gives 37 at $n = 6$, agreeing with Step 2, so it is safe to use in part (b).)

Step 5: Test whether 326 fits the rule

$$8n - 11 = 326$$

$$8n = 326 + 11 = 337$$

$$n = \frac{337}{8} = 42.125$$

(Reason: A term number counts positions, so n has to be a whole number. This value is not a whole number, so no position in the sequence produces 326.)

Step 6: Give the odd and even reason, and the two terms either side

$$8 \times 42 - 11 = 325$$

$$8 \times 43 - 11 = 333$$

(Reason: $8n$ is always even, and taking away the odd number 11 leaves an odd number, so every term of the sequence is odd. The sequence steps from 325 straight to 333, and the even number 326 is stepped over.)

(a)(i) 37

(a)(ii) Added 8 to the previous term

(b) Every term is odd, but 326 is even, so it cannot be a term

Verification

- ✓ **Check 1:** Write the sequence out one term further by adding 8: $-3, 5, 13, 21, 29, 37$. The sixth term is 37, which is what the rule gives at $n = 6$, so the two methods agree.
- ✓ **Check 2:** Count in the other direction from the rule: an even answer would need $8n - 11$ to be even, so $8n$ would have to be odd. $8n$ is a multiple of 8 and can never be odd, so no term of the sequence is even, and 326 is even.
- ✓ **Check 3:** Work out the terms on either side of 326: the 42nd term is 325 and the 43rd term is 333. 326 lies between two consecutive terms without being either of them, so it is skipped.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a)(i) 37	B1	37 written down as the next term. No working is needed for this mark.	✓
(a)(ii) Added 8	B1	Any clear statement of the rule, e.g. 'added 8', 'add 8', '+8', 'it goes up by 8', 'the rule is $8n - 11$ ', or the calculation $8 \times 6 - 11 = 37$.	✓
(b) Correct explanation	B1	Any correct explanation, e.g. the sequence is odd; 326 is even; the n th term $8n - 11$ is always odd; the sequence goes 325, 333; the 42nd term is 325; $\frac{337}{8} = 42.125$ is not a whole number; or 326 is not 11 less than a multiple of 8. Not accepted on its own: 'adding 8 each time will not lead to 326', 'it goes past 326', or any argument that divides 326 itself by 8 instead of 337.	✓

Full marks: 3/3

Question 8 - Exam Solution

Understanding the Question

Given

One box of screws costs £2.60, and one pack of washers costs £3.94
5 boxes of screws and 4 packs of washers are bought
The whole purchase is paid for with a single £50 note

Find

The change that should be given from the £50 note

Plan the Solution

- Cost the screws on their own: the price of one box multiplied by the number of boxes.
- Cost the washers on their own, in the same way.
- Add the two costs to get the total spent.
- Take that total away from £50, because the change is whatever is left of the note.

Worked Solution [3 marks]

Rule - Change: $\text{change} = \text{amount paid} - \text{total cost}$, and each item's cost is its price multiplied by the number bought, so the two costs must both be found before anything is subtracted.

Step 1: Work out the cost of the screws

$$5 \times 2.60 = 13.00$$

(Reason: 5 boxes at £2.60 each. Multiplying the price by the number of boxes is quicker and safer than adding £2.60 five times over.)

Step 2: Work out the cost of the washers

$$4 \times 3.94 = 15.76$$

(Reason: The washers come in packs, so it is the number of packs that multiplies £3.94, and each item must be costed with its own quantity, never with the other item's.)

Step 3: Add the two costs to get the total spent

$$13.00 + 15.76 = 28.76$$

(Reason: The screws and the washers are paid for together, so the shop takes £28.76 in one transaction.)

Step 4: Subtract the total from the amount handed over

$$50.00 - 28.76 = 21.24$$

(Reason: The £50 note covers the whole cost, so what is left of it is the change. Writing £50 as 50.00 lines the pence up under the pence before subtracting.)

£21.24

Verification

- ✓ **Check 1:** Redo the whole question in pence, where every value is a whole number and no decimal point can slip: $5 \times 260 = 1300$ and $4 \times 394 = 1576$, giving 2876 pence spent. $5000 - 2876 = 2124$ pence, which is £21.24, so the pounds working and the pence working agree exactly.
- ✓ **Check 2:** Subtract one cost at a time instead of adding them first. Take the screws off the note: $50.00 - 13.00 = 37.00$, then take the washers off what is left. $37.00 - 15.76 = 21.24$, the same change, reached without the two costs ever being added together.
- ✓ **Check 3:** Put the note back together: add the change to the total spent. $21.24 + 28.76 = 50.00$, exactly the amount handed over, so nothing has been counted twice and nothing has been dropped.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
A method to find the cost of the screws, or of the washers, or of both	M1	Any one of: 5×2.60 or 13; $50 - 5 \times 2.60$ or 37; 4×3.94 or 15.76; $50 - 4 \times 3.94$ or 34.24; or $5 \times 2.60 + 4 \times 3.94 (= 28.76)$.	✓
A complete method for the change	M1	For example $50 - (5 \times 2.60) - (4 \times 3.94)$, or $50 - 13 - 15.76$, or $50 - 28.76$, carried out on the candidate's own earlier values.	✓
The change, 21.24	A1	£21.24 on the answer line. Working is not required, so a correct answer scores full marks unless it comes from obviously incorrect working.	✓

Full marks: 3/3

Question 9 - Exam Solution

Understanding the Question

Given

(a) the product $c \times c \times c$ and (b) the product $12d \times 3e$

(c) the equation $\frac{k}{4} = 7$ and (d) the equation $2g - 3 = 6$

(e) the bracketed expression $x(x - 4)$

(f) the formula $P = 4y^2 + w$, with $y = -3$ and $w = 2$

Find

(a) a single power of c , and (b) one term in d and e (c) the value of k , and (d) the value of g (e) $x(x - 4)$ written without brackets (f) the value of P (note that y is negative, so the square is positive)

Plan the Solution

- (a) and (b) are simplifying: multiplying, so count how many of each letter there are and multiply the numbers separately.
- (c) and (d) are solving: undo whatever has been done to the letter, doing the same to both sides.
- (e) is expanding: multiply every term inside the bracket by the term outside.
- (f) is substituting: replace y and w by their values, then work out the power before the multiplication.

Worked Solution [8 marks]

Rule - four separate skills, one habit each. Multiplying powers of the same letter adds the indices, $a^m \times a^n = a^{m+n}$. Solving means applying the inverse operation to both sides. Expanding a bracket multiplies every term inside by the term outside. Substituting means replacing each letter by its value first, then following the order of operations - powers before multiplication.

Step 1 - part (a): add the indices

$$\begin{aligned} c \times c \times c &= c^1 \times c^1 \times c^1 \\ &= c^{1+1+1} = c^3 \end{aligned}$$

(Reason: (Reason: a letter on its own is that letter to the power 1, and multiplying powers of the same letter adds the indices, so three c s multiplied give c^3 .))

Step 2 - part (b): numbers first, then letters

$$\begin{aligned} 12d \times 3e &= 12 \times 3 \times d \times e \\ &= 36de \end{aligned}$$

(Reason: (Reason: multiplication can be done in any order, so gather the numbers, $12 \times 3 = 36$, and the letters, $d \times e = de$. The letters are different, so nothing else combines.))

Step 3 - part (c): undo the division

$$\frac{k}{4} = 7$$

$$k = 7 \times 4 = 28$$

(Reason: (Reason: k has been divided by 4, so the inverse is to multiply both sides by 4.))

Step 4 - part (d): clear the number term, then divide

$$2g - 3 = 6$$

$$2g = 6 + 3 = 9$$

$$g = \frac{9}{2} = 4.5$$

(Reason: (Reason: add 3 to both sides to leave $2g$ on its own, then divide both sides by 2. An answer of $\frac{9}{2}$ is equally acceptable.))

Step 5 - part (e): multiply both terms in the bracket

$$\begin{aligned} x(x - 4) &= x \times x - x \times 4 \\ &= x^2 - 4x \end{aligned}$$

(Reason: (Reason: the x outside multiplies the x and the -4 inside. Missing the second term is the usual slip here.))

Step 6 - part (f): substitute, then square before multiplying

$$P = 4y^2 + w$$

$$P = 4 \times (-3)^2 + 2$$

$$P = 4 \times 9 + 2 = 38$$

(Reason: (Reason: replace y by -3 and w by 2, then follow the order of operations - the power is worked out before the multiplication by 4, and only the y is squared, not the 4.))

(a) c^3

(b) $36de$

(c) $k = 28$

(d) $g = 4.5$

(e) $x^2 - 4x$

(f) $P = 38$

Verification

- ✓ **Check 1 - put numbers in place of the letters:** A simplified expression must give the same value as the original for every choice of letter. Try $c = 2$ in (a), $d = 5$ and $e = 2$ in (b), and $x = 3$ in (e). $2 \times 2 \times 2 = 8$ and $2^3 = 8$; $60 \times 6 = 360$ and $36 \times 5 \times 2 = 360$; $3(3 - 4) = -3$ and $3^2 - 4 \times 3 = -3$.
- ✓ **Check 2 - put the solutions back into the equations:** A solution is correct when it makes the original equation true, so substitute $k = 28$ into $\frac{k}{4} = 7$ and $g = 4.5$ into $2g - 3 = 6$. $\frac{28}{4} = 7$ and $2 \times 4.5 - 3 = 9 - 3 = 6$, so both equations balance.
- ✓ **Check 3 - part (f) a second way:** Fold the 4 into the square, since $4y^2 = (2y)^2$. This avoids the $4 \times y^2$ step altogether, and a negative multiplied by a negative is positive. $(2 \times -3)^2 + 2 = (-6)^2 + 2 = 36 + 2 = 38$, matching the value found by squaring first.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a) c^3	B1	Correct answer only.	✓
(b) $36de$	B1	Or equivalent, so $36ed$ is equally acceptable.	✓
(c) $k = 28$	B1	Correct answer only.	✓
(d) $2g = 6 + 3$ or $2g = 9$ or $g - \frac{3}{2} = \frac{6}{2}$ or $\frac{6 + 3}{2}$ or $\frac{9}{2}$	M1	For one correct first step - either clearing the -3 or dividing every term by 2. Or equivalent.	✓
(d) 4.5	A1	Or equivalent, eg $\frac{9}{2}$ or $4\frac{1}{2}$. Working is not required, so a correct answer scores full marks unless it follows obviously incorrect working.	✓
(e) $x^2 - 4x$	B1	Or $-4x + x^2$.	✓
(f) $4 \times (-3)^2 + 2$ or $4(-3)^2 + 2$ or $4 \times 9 + 2$ or $4(9) + 2$ or $4 \times -3 \times -3 + 2$	M1	For substituting values for y and w .	✓

Step	Mark	Description	Got it?
(f) 38	A1	Working is not required, so a correct answer scores full marks unless it follows obviously incorrect working. A common wrong answer here is a negative one, from squaring the minus sign away.	✓

Full marks: 8/8

Question 10 - Exam Solution

Understanding the Question

Given

Two sides of the square, PQ and QR , already drawn and meeting at a right angle at Q .
 $PQ = QR = 7$ cm, and every side of a square is the same length.
 A ruler and a pair of compasses, and nothing else.

Find

The fourth vertex, S , and the two sides that complete the square. Every construction arc, left on the page - the arcs are what the marks are for.

Plan the Solution

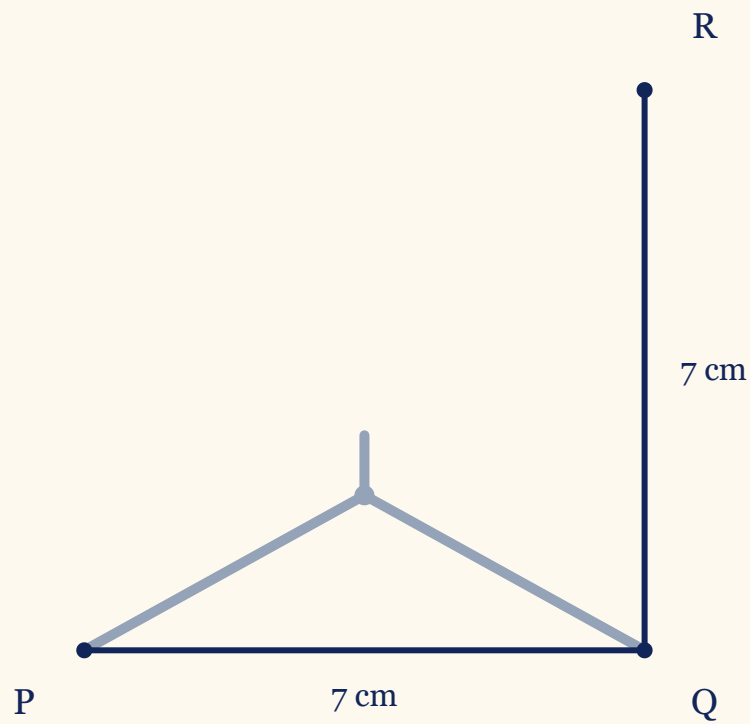
- The right angle at Q is already drawn, so nothing has to be constructed for it.
- The missing vertex is 7 cm from P and 7 cm from R , so it is where two arcs of radius 7 cm cross.
- Set the compasses once, across a side that is already drawn, and do not change them again.
- Join the crossing point to the two free ends with a ruler.

Worked Solution [2 marks]

Rule - Equal arcs: the point that is r from P and r from R is where an arc of radius r about P crosses an arc of radius r about R .

Step 1: Open the compasses to one whole side

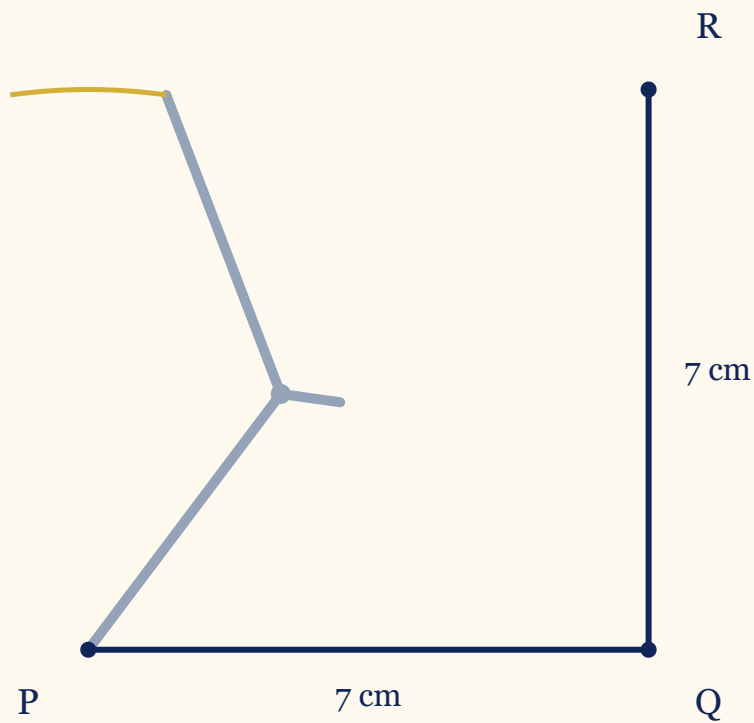
$$r = PQ = 7 \text{ cm}$$



(Reason: Every side of a square is the same length, so a side that is already drawn sets the radius exactly. Opening the compasses across PQ is more accurate than measuring with a ruler, and the compasses are not touched again.)

Step 2: Draw an arc from P

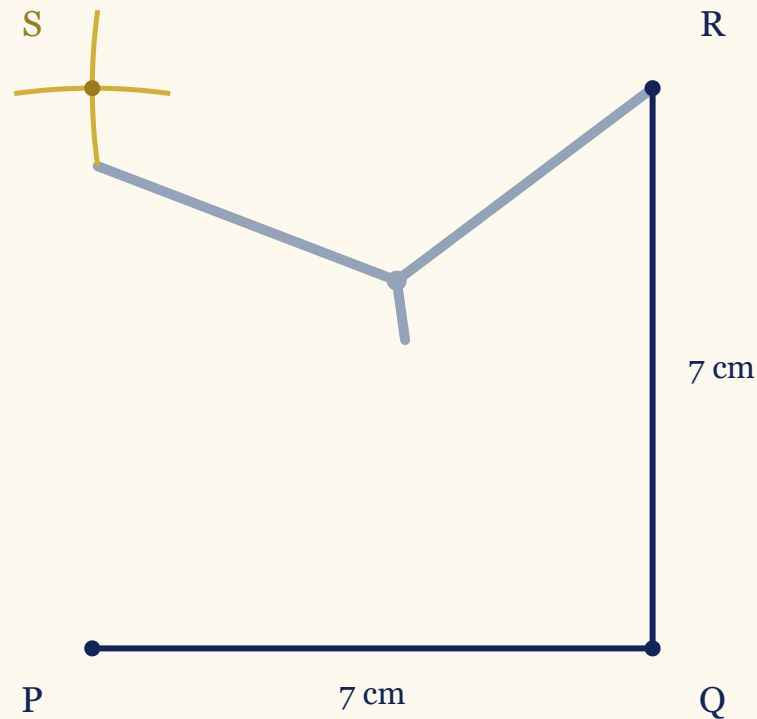
$PS = 7 \text{ cm}$



(Reason: The missing vertex is 7 cm from P , so it lies somewhere on this arc. Sweep enough of the arc to be sure it will reach the second one.)

Step 3: Draw a second arc from R , with the compasses unchanged

$$RS = 7 \text{ cm}$$



(Reason: The missing vertex is also 7 cm from R . The two arcs cross at that vertex, and the crossing is the construction - the point is not measured off a ruler.)

Step 4: Rule PS and SR

$$PS = SR = 7 \text{ cm}$$

$$\angle SPQ = \angle SRQ = 90^\circ$$

- ✓ **Check 3:** Check the reach of the compasses independently of the drawing. The centres are 9.9 cm apart and the two radii add to $7 + 7 = 14$ cm. $14 > 9.9$, so a crossing point had to exist

Mark Scheme Breakdown

Step	Mark	Description	Got it?
Arcs of radius 7 cm drawn from P and from R , crossing at S , with PS and SR ruled in	B2	For a fully correct square with arcs shown.	✓
Part of the construction correct, but not all of it	B1	For a correctly sized square with no arcs shown, or for an incorrect quadrilateral with arcs of equal radius shown, or for correct arcs not joined - all within or on the guidelines of the overlay.	✓

Full marks: 2/2

Question 11 - Exam Solution

Understanding the Question

Given

A tea room sells 4 types of tart, coded cherry (C), fig (F), lemon (L) and maple (M).
Amara chooses 2 different types.
A two-way table of iced teas sold on Saturday and on Sunday, with four entries missing.
100 visitors are asked, and 33 of them prefer tarts.

Find

(a) every possible pair of tart types Amara can choose (b) the four missing entries of the two-way table (c) the probability that a visitor chosen at random does not prefer tarts

Plan the Solution

- (a) List in a fixed order: take each type in turn and pair it only with the types that come after it. An ordered list is what makes a missed pair or a repeat impossible to hide.

- (b) Every row adds to its row total and every column adds to its column total. Start at the line with only one gap in it, then use each new entry to open up the next line.
- (c) Preferring tarts and not preferring tarts are complementary, so the two counts add to 100.

Worked Solution [5 marks]

Rule - Two-way table: every row adds to its row total, every column adds to its column total, and the grand total is the sum of the row totals and also the sum of the column totals. Complementary events: the probability that something does not happen is 1 minus the probability that it does.

Part (a): pair the first type with every later type

CF, CL, CM

	Peach	Berry	Ginger	Total
Saturday	32	11	28	71
Sunday	16	20	13	49
Total	48	31	41	120

(Reason: Fix cherry first and run through the types that come after it: fig, lemon, then maple. Working in a fixed order is what keeps the list complete.)

Part (a): the pairs that do not use cherry

FL, FM

LM

$$3 + 2 + 1 = 6$$

(Reason: Fig pairs with lemon and with maple, and lemon pairs with maple. That is $3 + 2 + 1 = 6$ pairs in all, so nothing has been missed and nothing has been counted twice.)

Part (b): the Sunday row has only one gap

$$49 - 20 - 13 = 16$$

(Reason: The Sunday row adds to 49, and two of its three flavours are already given, so the peach entry is whatever is left over.)

Part (b): the peach column now has only one gap

$$48 - 16 = 32$$

(Reason: The peach column adds to 48, and the Sunday peach entry has just been found, so the Saturday peach entry is the difference.)

Part (b): the two totals that are left

$$32 + 11 + 28 = 71$$

$$71 + 49 = 120$$

(Reason: The Saturday row can now be added across, and the two row totals give the overall total. The column totals give the same figure, $48 + 31 + 41 = 120$.)

Part (c): take the complement

$$100 - 33 = 67$$

$$\frac{100 - 33}{100} = \frac{67}{100}$$

(Reason: Every visitor either prefers tarts or does not, so the 67 who do not are out of the 100 who were asked.)

(a) CF, CL, CM, FL, FM, LM

**(b) Saturday peach 32, Saturday total 71, Sunday peach 16,
overall total 120**

$$\text{(c)} \quad \frac{67}{100}$$

Verification

- ✓ **Check 1:** Add each row across the completed table: $32 + 11 + 28 = 71$ and $16 + 20 + 13 = 49$. Both row totals are the ones the table already carried.
- ✓ **Check 2:** Add each column down: $32 + 16 = 48$, $11 + 20 = 31$ and $28 + 13 = 41$. All three column totals agree with the printed ones.
- ✓ **Check 3:** Reach the overall total the other way round: $48 + 31 + 41 = 120$, against $71 + 49 = 120$ from the rows. The rows and the columns give the same overall total.
- ✓ **Check 4:** Count the combinations with the pair count for 2 chosen from 4: $\frac{4 \times 3}{2} = 6$.
Six pairs were listed, and no pair appears twice.
- ✓ **Check 5:** Add the two probabilities: $\frac{33}{100} + \frac{67}{100} = 1$. The two outcomes are complementary, as they must be.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a) All six combinations listed: CF, CL, CM, FL, FM, LM	B2	for all 6 combinations, with no extras and no repeats	✓
(a) A partial list	(B1)	for at least 3 correct combinations, ignoring repeats	✓
(b) Correct two-way table: 32 and 71 on the Saturday row, 16 on the Sunday row, 120 as the overall total	B2	for all 4 correct values	✓
(b) A partly completed table	(B1)	for 2 or 3 correct values	✓
(c) $\frac{67}{100}$	B1	oe, so 0.67 and 67% are equally acceptable	✓
Full marks: 5/5			

Question 12 - Exam Solution

Understanding the Question

Given

The polygon is regular, so all of its sides
and all of its angles are equal.
Each exterior angle is 15°

Find

The number of sides, n .

Plan the Solution

- Use the fact that the exterior angles of any polygon add up to one full turn.
- A regular polygon has n equal exterior angles, so each one is $\frac{360}{n}$ degrees.
- Set that equal to 15 and solve for n .

Worked Solution [2 marks]

Rule - Exterior angles: the exterior angles of any polygon add up to 360° , so for a regular polygon with n sides each exterior angle is $\frac{360^\circ}{n}$.

Step 1: Write down the exterior angle fact

sum of the exterior angles = 360°

(Reason: (Reason: walking once around the outside of any polygon turns you through one complete turn, which is 360° . This is true whatever the number of sides.))

Step 2: Turn that into an equation

$$15n = 360$$

(Reason: (Reason: the polygon is regular, so all n of its exterior angles are the same size, 15° , and together they make 360° .)

Step 3: Solve for the number of sides

$$n = \frac{360}{15} = 24$$

(Reason: (Reason: divide both sides of $15n = 360$ by 15. A calculator is allowed here, but the division is worth doing in your head as a check.))

24 sides

Verification

- ✓ **Check 1:** Multiply back. If there are 24 exterior angles of 15° , they must add to exactly one full turn. $24 \times 15 = 360$
- ✓ **Check 2:** Go the other way, through the interior angle. Each interior angle is $180 - 15 = 165$ degrees, and the interior angles of an n -sided polygon add to $(n - 2) \times 180$ degrees, which is $22 \times 180 = 3960$ degrees here. $\frac{3960}{165} = 24$
- ✓ **Check 3:** Compare with a polygon whose sides you already know. A regular hexagon has 6 sides and an exterior angle of 60° . Our exterior angle is a quarter of that, and a smaller exterior angle means more sides, so expect four times as many. $4 \times 6 = 24$

Mark Scheme Breakdown

Step	Mark	Description	Got it?
Divide one full turn by the size of one exterior angle, or set the interior angle equal to $180 - 15$.	M1	for $\frac{360}{15}$ oe, or for $\frac{(n-2) \times 180}{n} = 180 - 15$	✓
State the number of sides.	A1	24	✓
Note	-	Working not required, so a correct answer scores full marks (unless it comes from obviously incorrect working).	✓

Full marks: 2/2

Question 13 - Exam Solution

Understanding the Question

Given

The equation $y = 5 - 2x$

The values of x to use: every whole number from -2 to 3

A grid running from -2 to 11 up the y axis

Find

The straight line $y = 5 - 2x$, drawn on the grid from $x = -2$ to $x = 3$

Plan the Solution

- Work out y for each whole number value of x from -2 to 3 .
- Set the six pairs out as a table, so nothing is lost between the arithmetic and the plotting.
- Plot the six points, check they lie in a straight line, then rule ONE line across the whole range.

Worked Solution [3 marks]

Rule - Table of values: substitute each value of x into $y = 5 - 2x$, plot each pair (x, y) , then join them with one ruled straight line.

Step 1: substitute each value of x

$$5 - 2 \times (-2) = 5 + 4 = 9$$

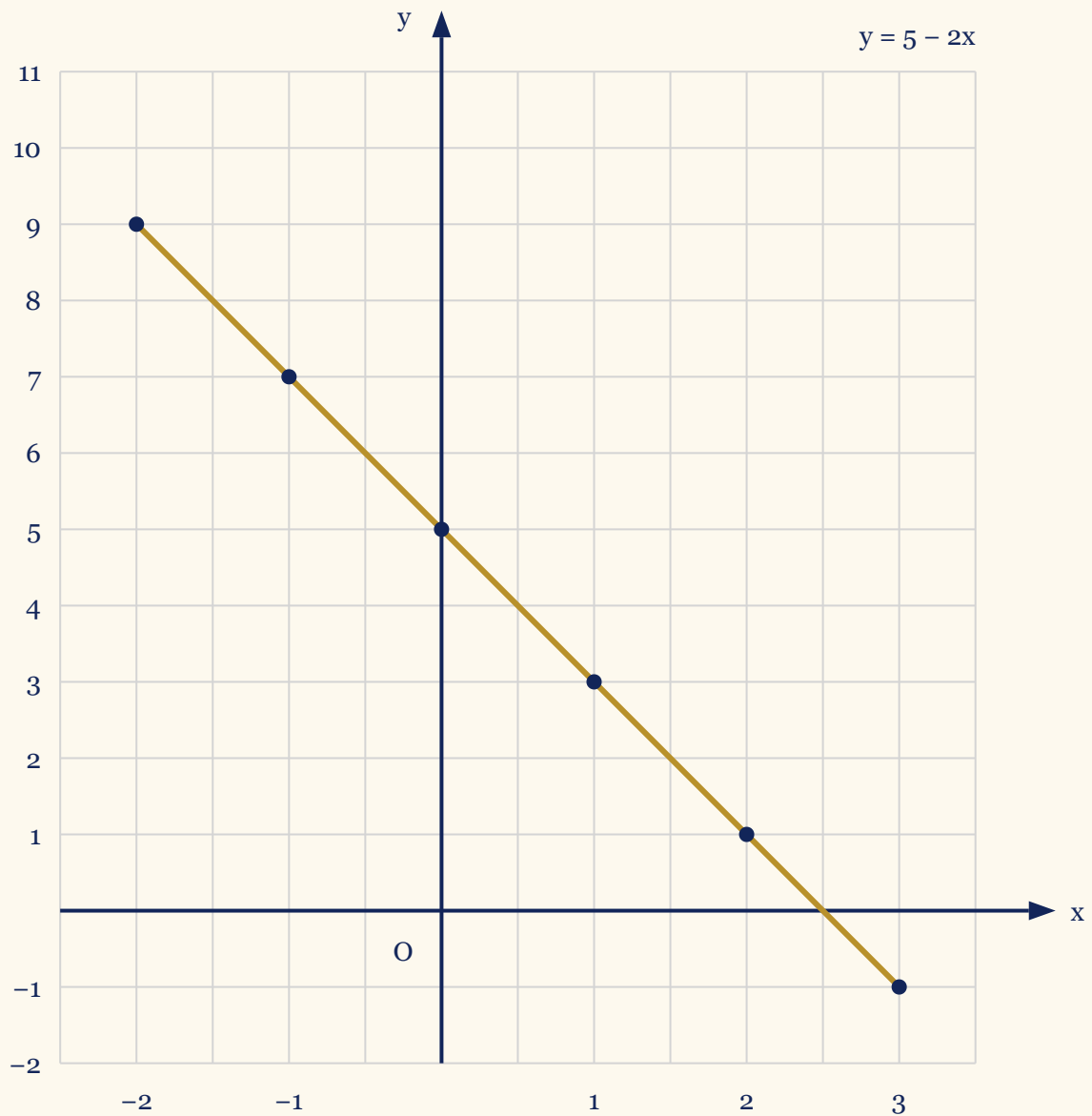
$$5 - 2 \times (-1) = 5 + 2 = 7$$

$$5 - 2 \times 0 = 5 - 0 = 5$$

$$5 - 2 \times 1 = 5 - 2 = 3$$

$$5 - 2 \times 2 = 5 - 4 = 1$$

$$5 - 2 \times 3 = 5 - 6 = -1$$



(Reason: (Reason: multiply first, then subtract. Take care with a negative value of x : subtracting 2 lots of a negative number ADDS, so the y value goes up on the left of the axis.))

Step 2: set the results out as a table

x	-2	-1	0	1	2	3
y	9	7	5	3	1	-1

(Reason: (Reason: read the bottom row across - it falls 9, 7, 5, 3, 1, -1, down by 2 every time. A constant step is the sign of a straight line, so a value that breaks the pattern is an arithmetic slip, caught before anything is plotted.))

Step 3: plot the points and rule the line

$(-2, 9), (-1, 7), (0, 5), (1, 3), (2, 1), (3, -1)$

$$-2 \leq x \leq 3$$

(Reason: (Reason: each column of the table is one point, x across then y up. Join them with a single ruled line that reaches both ends of the range - a line stopping short of $x = -2$ or $x = 3$ does not answer the question.))

The ruled straight line through $(-2, 9)$, $(0, 5)$ and $(3, -1)$, drawn right across the grid from $x = -2$ to $x = 3$

Verification

- ✓ **Check 1 - the gradient:** The equation is in the form $y = mx + c$, so the line must fall 2 for every 1 across. From $(-2, 9)$ to $(3, -1)$ the drawn line falls 10 over a run of 5.

$$\frac{-10}{5} = -2$$

- ✓ **Check 2 - the intercept:** Where the drawn line crosses the y axis, x is 0, so the reading there should be the constant term of the equation. $5 - 2 \times 0 = 5$

- ✓ **Check 3 - a point read back off the line:** Pick a point in the middle of the range that was not used to set the ruler: at $x = 2$ the drawn line should pass through $(2, 1)$.

$$5 - 2 \times 2 = 1$$

Mark Scheme Breakdown

Step	Mark	Description	Got it?
State at least two correct points, or draw a line of negative gradient through $(0, 5)$, or draw a line of gradient -2	B1	The first of the three marks. Any two correct pairs are enough, and they may be written in a table rather than plotted - for example $(0, 5)$ and $(1, 3)$.	✓
Draw a correct straight line segment through at least three of the six points, or plot all six points without joining them	B2	The six points are $(-2, 9)$, $(-1, 7)$, $(0, 5)$, $(1, 3)$, $(2, 1)$, $(3, -1)$. A line of gradient -2 through $(0, 5)$ that does not run the full range also earns this.	✓

Step	Mark	Description	Got it?
Draw the correct line right across, from $x = -2$ to $x = 3$	B3	Full marks. The line must be straight, ruled, and reach both ends of the stated range; a correct segment that stops short scores B2 only.	✓

Full marks: 3/3

Question 14 - Exam Solution

Understanding the Question

Given

A total of 1200 euros is shared between three people.

Shalini gets $\frac{1}{5}$ of the 1200 euros.

Marta gets 42% of the 1200 euros.

Lucas gets whatever is left of the 1200 euros.

Shalini's money : Lucas's money = $1 : n$,
so the ratio has already been scaled to start at 1.

Find

The value of n . Because the first number of the ratio is 1, n is how many times Lucas's share is bigger than Shalini's, so expect a decimal rather than a whole number.

Plan the Solution

- Work out Shalini's share, which is a fraction of the 1200 euros.
- Work out Marta's share, which is a percentage of the same 1200 euros.
- Take BOTH of those shares away from 1200 to find Lucas's share. "The rest" means what is left after the other two have been paid, not after one of them.
- Write Shalini's share : Lucas's share, then divide both parts by Shalini's share so the ratio starts at 1.

Worked Solution [4 marks]

Rule - to write a ratio $a : b$ in the form $1 : n$, divide both parts by the first part, which

gives $n = \frac{b}{a}$.

Step 1: Shalini's share

$$\frac{1}{5} \times 1200 = 240$$

(Reason: (Reason: a fifth of a quantity is that quantity split into 5 equal parts, so 1200 splits into parts of 240 euros.))

Step 2: Marta's share

$$\frac{42}{100} \times 1200 = 0.42 \times 1200$$

$$0.42 \times 1200 = 504$$

(Reason: (Reason: 42% means 42 hundredths, and $\frac{42}{100} = 0.42$, so the percentage becomes a multiplier. Both shares are taken from the SAME 1200 euros.))

Step 3: Lucas's share, which is the rest

$$240 + 504 = 744$$

$$1200 - 744 = 456$$

(Reason: (Reason: Shalini's and Marta's money has already gone out of the 1200 euros, so what is left over belongs to Lucas.))

Step 4: write the ratio in the form 1 : n

$$240 : 456$$

$$n = \frac{456}{240} = 1.9$$

(Reason: (Reason: dividing both parts of 240 : 456 by 240 leaves 1 on the left, which is the form the question asks for, so the right-hand part is n.))

$$n = 1.9$$

Verification

✓ **Check 1:** Add the three shares back together. Nothing may be left over and nothing may be created, so they must come to exactly 1200 euros. $240 + 504 + 456 = 1200$

✓ **Check 2:** Redo it without any euros at all, in fractions of the whole. Shalini has $\frac{1}{5} = \frac{20}{100}$ and Marta has $\frac{42}{100}$, so together they have $\frac{62}{100}$ and Lucas is left with $\frac{38}{100}$. The ratio is then 38 hundredths against 20 hundredths. $n = \frac{38}{20} = 1.9$

✓ **Check 3:** Run the ratio forwards instead of backwards. If $1 : 1.9$ is right, then multiplying Shalini's 240 euros by 1.9 must land on Lucas's share. $1.9 \times 240 = 456$

Mark Scheme Breakdown

Step	Mark	Description	Got it?
Find $\frac{1}{5}$ of 1200	M1	For $\frac{1}{5} \times 1200 = 240$ or $\frac{1200}{5} = 240$ oe. Also awarded for 20% or 0.2 or 0.42 or $\frac{42}{100}$ seen.	✓
Find 42% of 1200	M1	For $0.42 \times 1200 = 504$ or $\frac{42}{100} \times 1200 = 504$ oe, or for the combined share $\frac{1}{5} + \frac{42}{100} = \frac{62}{100}$ oe, or $0.2 + 0.42 = 0.62$, or $20 + 42 = 62$. Award both method marks (M2) for 744 seen.	✓
Subtract both shares from 1200	M1	For $1200 - (240 + 504) = 456$ oe, or $1200 - 744 = 456$. Follow through on the candidate's own two shares. Also awarded in fraction form for $1 - \frac{62}{100} = \frac{38}{100} = \frac{19}{50}$ oe, or $1 - 0.62 = 0.38$, or $100 - 62 = 38$.	✓
State the value of n	A1	1.9 oe, so $\frac{19}{10}$ and $1\frac{9}{10}$ are equally acceptable. Working is not required, so a correct answer scores full marks unless it comes from obviously incorrect working.	✓

Full marks: 4/4

Question 15 - Exam Solution

Understanding the Question

Given

A frequency table of the number of plums in a punnet, taking the values 11, 12, 13, 14, 15 and 16.

Find

(a) The mode of the number of plums in a punnet. (b) The mean number of plums in a punnet.

The matching frequencies are 7, 8, 7, 5, 1 and 2.

There are 30 punnets altogether, so the frequencies must add to 30.

Plan the Solution

- For the mode, read down the frequency column and find the largest frequency. The mode is the value beside it, not the frequency itself.
- For the mean, multiply each number of plums by its frequency, add those products to get the total number of plums, then divide by the total frequency.
- Check the frequencies add to 30 before dividing, because that total is the divisor.

Worked Solution [4 marks]

Rule - Averages from a frequency table: the mode is the value with the largest frequency, and mean = $\frac{\Sigma fx}{\Sigma f}$, where x is a value and f is its frequency.

Part (a): find the largest frequency

largest frequency = 8

mode = 12

(Reason: The frequency column counts how often each value occurs, so the value that occurs most often sits beside the largest frequency. That frequency is 8, on the 12 row, so the mode is 12 plums. The mode is the value 12, never the count 8.)

Part (b): multiply each number of plums by its frequency

$$11 \times 7 = 77$$

$$12 \times 8 = 96$$

$$13 \times 7 = 91$$

$$14 \times 5 = 70$$

$$15 \times 1 = 15$$

$$16 \times 2 = 32$$

(Reason: Each product is the total number of plums held by the punnets on that row: 7 punnets with 11 plums in each hold 77 plums between them. Take the frequency from the same row as the value.)

Add the products to find the total number of plums

$$77 + 96 + 91 + 70 + 15 + 32 = 381$$

(Reason: Adding the six products counts every plum in all 30 punnets, giving 381 plums altogether.)

Divide the total by the number of punnets

$$\text{mean} = \frac{381}{30} = 12.7$$

(Reason: The 381 plums are shared between 30 punnets. A mean does not have to be a whole number, so 12.7 is a proper final answer and should not be rounded unless the question asks for it.)

(a) 12

(b) 12.7

Verification

- ✓ **Check 1:** Add the frequency column on its own: $7 + 8 + 7 + 5 + 1 + 2 = 30$. The frequencies total 30, the number of punnets the question gives, so 30 is the right divisor.
- ✓ **Check 2:** Ignore the table and think of the 30 punnets listed one by one. The reading 12 appears 8 times, while 11 and 13 each appear only 7 times. The most common reading is 12, which agrees with part (a).
- ✓ **Check 3:** Work the mean out a different way. Take 11 off every value and average what is left: $0 \times 7 + 1 \times 8 + 2 \times 7 + 3 \times 5 + 4 \times 1 + 5 \times 2 = 51$, then $\frac{51}{30} = 1.7$.
 $11 + 1.7 = 12.7$, which agrees with part (b). The mean also lies between 11 and 16, as any mean of these values must.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a) Write down the value with the largest frequency	B1	12	✓
(b) Multiply each number of plums by its frequency	M1	For at least four correct products, e.g. $11 \times 7 + 12 \times 8 + 13 \times 7 + 14 \times 5 + 15 \times 1 + 16 \times 2$ or $77 + 96 + 91 + 70 + 15 + 32$, leading to 381.	✓
Divide the total by the total frequency	M1	Their total divided by 30, e.g. $\frac{381}{30}$.	✓
Give the mean	A1	12.7. Working is not required, so a correct answer scores full marks unless it comes from obviously	✓

Step	Mark	Description	Got it?
		incorrect working. Allow 13 if both method marks are scored, since that is 12.7 rounded to the nearest whole plum.	

Full marks: 4/4

Question 16 - Exam Solution

Understanding the Question

Given

Wednesday: 375 jars per hour, for 8 hours

Thursday: 20% more jars in total than on Wednesday

Thursday: 300 jars per hour

Find

The number of hours the plant made jars on Thursday

Plan the Solution

- Multiply Wednesday's hourly rate by Wednesday's hours to get Wednesday's total.
- Increase that total by 20% to get Thursday's total. Notice that the two hourly rates are different, so Thursday's total cannot be found from Wednesday's rate.
- Divide Thursday's total by 300 jars per hour to get the number of hours.

Worked Solution [4 marks]

Rule - Rate: number made = hourly rate multiplied by number of hours, so number of hours = $\frac{\text{number made}}{\text{hourly rate}}$

Step 1: Work out how many jars were made on Wednesday

$$375 \times 8 = 3000$$

(Reason: The plant made 375 jars in each of 8 hours, so the total is the hourly rate multiplied by the number of hours.)

Step 2: Increase Wednesday's total by 20%

$$100\% + 20\% = 120\% = 1.2$$

$$3000 \times 1.2 = 3600$$

(Reason: 20% more means 120% of Wednesday's total, and 120% as a decimal multiplier is 1.2. Adding 20% of 3000, which is 600, to 3000 gives the same total.)

Step 3: Divide Thursday's total by Thursday's hourly rate

$$\frac{3600}{300} = 12$$

(Reason: Every hour on Thursday produced 300 jars, so the number of hours is Thursday's total shared into groups of 300.)

12 hours

Verification

- ✓ **Check 1:** Work forwards from the answer. Make 300 jars an hour for 12 hours, then compare that total with Wednesday's 3000. $300 \times 12 = 3600$, and $\frac{3600 - 3000}{3000} = 0.2$, which is exactly 20% more
- ✓ **Check 2:** Reach the answer a different way, by proportion, without finding either total. Thursday's rate is $\frac{300}{375} = \frac{4}{5}$ of Wednesday's rate, while Thursday's output is $\frac{6}{5}$ of Wednesday's output, so the time must scale by $\frac{6}{5} \times \frac{5}{4} = \frac{3}{2}$, and $\frac{3}{2} \times 8 = 12$ hours, which agrees
- ✓ **Check 3:** Sense check. Thursday's rate of 300 an hour is slower than Wednesday's 375 an hour, yet more jars were made, so Thursday must have taken longer than Wednesday's 8 hours. 12 hours is longer than 8 hours, as expected

Mark Scheme Breakdown

Step	Mark	Description	Got it?
$375 \times 8 (= 3000)$	M1	For a complete method to find the number of jars made on Wednesday. Award for 3000 seen anywhere.	✓
$375 \times 8 \times 1.2 (= 3600)$	M1	For a complete method to find the number of jars made on Thursday, using their Wednesday total. Also award for $3000 \times \left(1 + \frac{20}{100}\right)$ or 1.2×3000 or $(0.2 \times 3000) + 3000$ or $600 + 3000$.	✓

Step	Mark	Description	Got it?
$\frac{3600}{300}$	M1	For dividing their Thursday total by 300 jars per hour.	✓
12	A1	Working not required, so a correct answer scores full marks, unless it comes from obviously incorrect working.	✓

Full marks: 4/4

Question 17 - Exam Solution

Understanding the Question

Given

The number 1400, to be broken down into primes.

Find

The product of powers of primes that makes 1400, written in index form.

Plan the Solution

- Divide by the smallest prime that goes in, and keep dividing by that same prime for as long as it goes in.
- Move up to the next prime and repeat, stopping when the number left is itself prime.
- Count how many times each prime was used and write that count as a power, which is what index form means.

Worked Solution [3 marks]

Rule - Prime factorisation: keep dividing by the smallest prime that goes in until 1 is reached. The divisors used, collected as powers, are the answer.

Step 1: divide by the smallest prime, 2, for as long as it goes in

$$\frac{1400}{2} = 700$$

$$\frac{700}{2} = 350$$

$$\frac{350}{2} = 175$$

(Reason: 1400 is even, so 2 divides it. Carry on until the number left is odd: 175 is odd, so 2 will not go again.)

Step 2: move up to the next prime that goes in, 5

$$\frac{175}{5} = 35$$

$$\frac{35}{5} = 7$$

(Reason: 3 is skipped because $1 + 7 + 5 = 13$ is not a multiple of 3, and 175 ends in a 5, so 5 is the next prime that divides.)

Step 3: stop when the number left is itself prime

$$\frac{7}{7} = 1$$

$$1400 = 2 \times 2 \times 2 \times 5 \times 5 \times 7$$

(Reason: 7 is prime, so the ladder ends there. The divisors used down the ladder are the prime factors of 1400.)

Step 4: collect the repeated primes as powers

$$1400 = 2^3 \times 5^2 \times 7$$

(Reason: There are three 2s, two 5s and one 7, and writing those counts as powers is what puts the answer in index form.)

$$2^3 \times 5^2 \times 7$$

Verification

✓ **Check 1:** Multiply the powers back together. $2^3 = 8$ and $5^2 = 25$. $8 \times 25 \times 7 = 1400$

✓ **Check 2:** Split 1400 a completely different way, as 14×100 , and factorise each piece on its own. $(2 \times 7) \times (2^2 \times 5^2) = 2^3 \times 5^2 \times 7$

✓ **Check 3:** Divide 1400 by the powers one at a time. A correct factorisation lands exactly on

$$1. \frac{1400}{8} = 175, \text{ then } \frac{175}{25} = 7, \text{ then } \frac{7}{7} = 1$$

Mark Scheme Breakdown

Step	Mark	Description	Got it?
Start the prime factorisation, e.g.	M1	For two correct stages of prime factorisation with no incorrect stage, or for at least three stages with no more than one incorrect stage. Each stage gives two	✓

Step	Mark	Description	Got it?
$1400 = 2 \times 2 \times 350$		factors, and it may be shown in a factor tree, a ladder or a list, e.g. 2, 2, 350. Other openings such as $2 \times 7 \times 100$ or $5 \times 7 \times 40$ score the same.	
Reach the complete list of primes, $2 \times 2 \times 2 \times 5 \times 5 \times 7$	M1	Dependent on the first M1. Awarded for $2 \times 2 \times 2 \times 5 \times 5 \times 7$, or for the primes listed as $2^3, 5^2, 7$. Ignore any 1s. It may be seen in a fully correct factor tree or ladder rather than written out.	✓
Write the answer in index form, $2^3 \times 5^2 \times 7$	A1	Dependent on both method marks. The factors may be given in any order, but the answer must be in index form as the question asks, and a 1 in the final answer is not allowed.	✓
Note - working required	-	The question asks for the working to be shown, so the answer on its own earns nothing. This row carries no mark of its own.	✓

Full marks: 3/3

Question 18 - Exam Solution

Understanding the Question

Given

Shape A has vertices $(2, 1)$, $(2, 2)$, $(3, 2)$ and $(4, 1)$.

Shape B has vertices $(5, -4)$, $(5, -3)$, $(6, -3)$ and $(7, -4)$.

Both are trapeziums of the same size, drawn on a grid running from -8 to 8 on each axis.

Find

(a) The single transformation that maps A onto B , named in full and with its vector. (b) The image of A after a rotation of 180° about $(-1, 0)$, drawn on the grid and labelled C .

Plan the Solution

- Compare the two shapes first. B is the same size as A and the same way up, so nothing has been turned, flipped or resized. That leaves a translation.
- Pick one vertex, and the vertex in the matching position on the other shape, then subtract to get the vector. Repeating that for all four vertices is what proves it really is a translation.

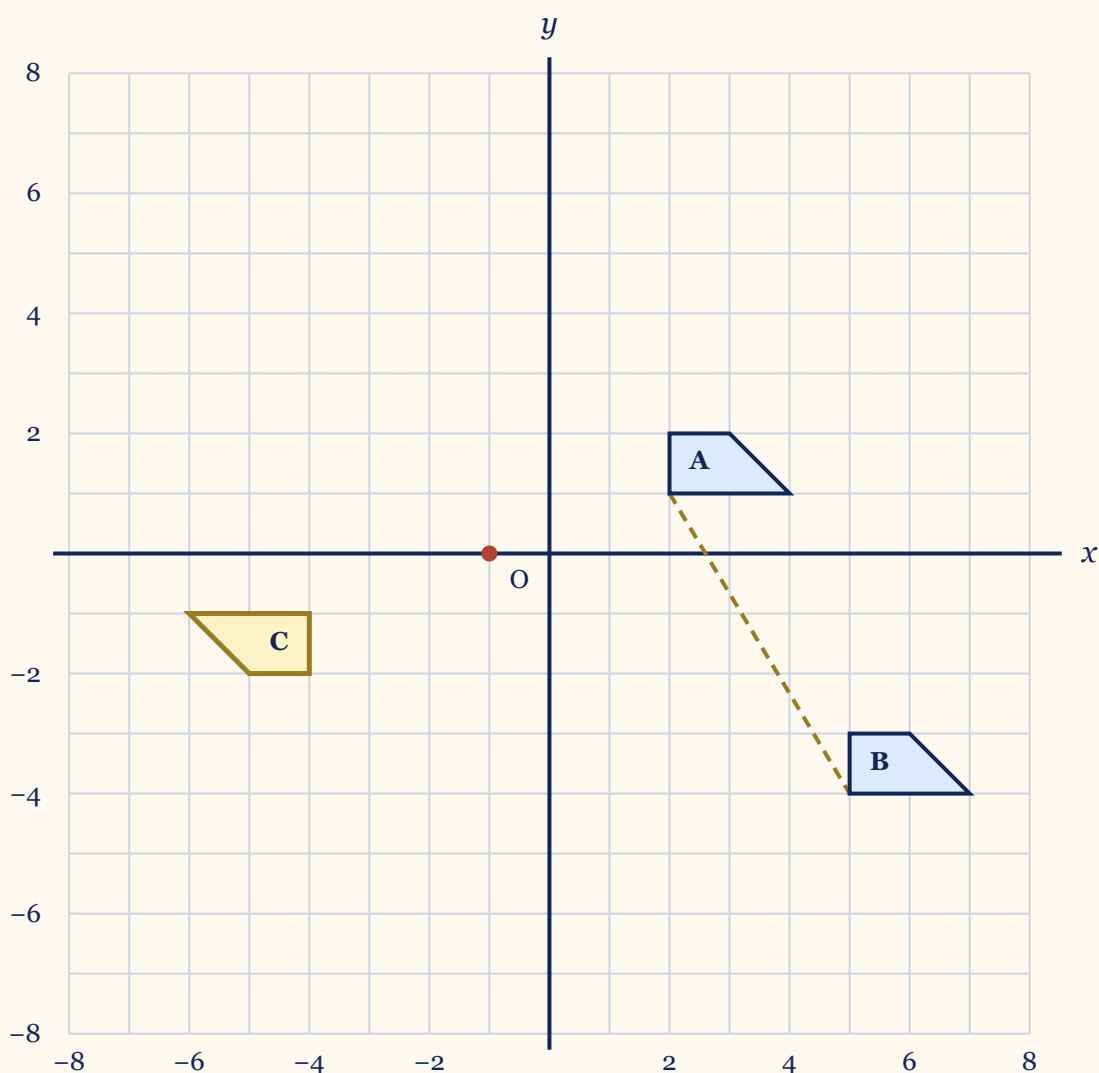
- For part (b), a rotation of 180° is a half turn: every point finishes on the opposite side of the centre, the same distance away.
- Rotate the four vertices one at a time, join them in the same order, and write C inside the new shape.

Worked Solution [4 marks]

Rule - Translation: the vector from (x_1, y_1) to (x_2, y_2) is $\begin{pmatrix} x_2 - x_1 \\ y_2 - y_1 \end{pmatrix}$. Rotation of 180° about (a, b) : $(x, y) \rightarrow (2a - x, 2b - y)$.

Step 1: Decide what kind of transformation part (a) is

same size, same way up $\implies$ a translation



(Reason: Shape B is not turned, not flipped and not a different size, so it cannot be a rotation, a reflection or an enlargement. A translation is the only single transformation left, and naming any of the others alongside it loses the mark.)

Step 2: Match a pair of corresponding vertices

$$(2, 1) \rightarrow (5, -4)$$

(Reason: Take the bottom left vertex of A and the bottom left vertex of B . Matching by position on the shape is what matters; pairing the wrong two vertices gives the wrong vector.)

Step 3: Subtract to find the translation vector

$$5 - 2 = 3$$

$$-4 - 1 = -5$$

$$\begin{pmatrix} 3 \\ -5 \end{pmatrix}$$

(Reason: Image coordinate minus object coordinate, the x values first and then the y values. A positive top number means right, and a negative bottom number means down, so this is 3 right and 5 down.)

Step 4: Write down the half turn rule for part (b)

$$(x, y) \rightarrow (2a - x, 2b - y)$$

$$(x, y) \rightarrow (-2 - x, -y)$$

(Reason: The centre is $(a, b) = (-1, 0)$, so $2a = -2$ and $2b = 0$. A half turn needs no protractor: each image point sits the same distance from the centre, on the opposite side of it.)

Step 5: Rotate each vertex of shape A

$$(2, 1) \rightarrow (-4, -1)$$

$$(2, 2) \rightarrow (-4, -2)$$

$$(3, 2) \rightarrow (-5, -2)$$

$$(4, 1) \rightarrow (-6, -1)$$

(Reason: Substitute the vertices into the rule one at a time. Working down the list in order keeps the image vertices in the same order as the original ones, which is what makes joining them up straightforward.)

Step 6: Join the image points in order and label the shape

$$(-6, -1) \quad (-4, -1) \quad (-4, -2) \quad (-5, -2)$$

(Reason: Join the four image points in the same order as the vertices of A , so the sloping edge still sits opposite the vertical edge. Then write C inside the shape, because the question asks for it to be labelled.)

(a) Translation by the vector $\begin{pmatrix} 3 \\ -5 \end{pmatrix}$

(b) C drawn at $(-6, -1)$, $(-4, -1)$, $(-4, -2)$ and $(-5, -2)$

Verification

- ✓ **Check 1:** Undo the translation. Take 3 off the x coordinate of a vertex of B , and add 5 to its y coordinate. $5 - 3 = 2$ and $-4 + 5 = 1$, so $(5, -4)$ goes back to $(2, 1)$, which is a vertex of A .
- ✓ **Check 2:** Subtract all four corresponding pairs, not just the one used in the working. A translation moves every point by the same vector. All four pairs give 3 across and 5 down, so one single vector carries the whole shape and the transformation really is a translation.
- ✓ **Check 3:** The centre of a half turn is the midpoint of every point and its image, so test the midpoints instead of repeating the rule. The midpoint of $(2, 1)$ and $(-4, -1)$ is $(-1, 0)$, and the other three pairs give $(-1, 0)$ as well.
- ✓ **Check 4:** A rotation cannot change the size or shape of anything, so compare the edges of C with the edges of A . Each shape has a vertical edge of 1 square, a short horizontal edge of 1 square, a sloping edge across one square, and a long horizontal edge of 2 squares, so C is congruent to A .

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a) Name the transformation	B1	for translation. No mark if reflection, rotation, enlargement, mirrored, turned, move or flipped is stated as well. Move together with translation is acceptable, and a misspelling such as translat is allowed.	✓
(a) Give the vector	B1	for (vector =) $\begin{pmatrix} 3 \\ -5 \end{pmatrix}$	✓
(b) Draw the image and label it	B2	for the shape drawn at $(-6, -1)$ $(-4, -1)$ $(-4, -2)$ $(-5, -2)$. Condone a missing label.	✓
(b) Partial credit	B1	if not B2, for a correct trapezium drawn with the correct orientation in the wrong position, or for 3 points plotted correctly. The commonest cause of both is rotating about the origin instead of about $(-1, 0)$.	✓

Full marks: 4/4

Question 19 - Exam Solution

Understanding the Question

Given

The list $x, x, y, 15$, written in ascending order of size, with x and y both integers. The four numbers have a median of 12.5 and a range of 4.

Find

The value of x and the value of y .

Plan the Solution

- The range uses only the smallest and the largest number. Ascending order fixes which is which, so the range gives an equation containing x on its own - start there.
- With four numbers there is no single middle one, so the median is the mean of the middle two, x and y . That gives a second equation linking the two letters.
- Put the value of x into that second equation to get y , then read the finished list back to confirm it is still ascending and both numbers are integers.

Worked Solution [2 marks]

Rule - Range and median: range = largest – smallest, and for an even amount of numbers in order the median is the mean of the middle two.

Step 1: use the range, which involves only the two ends of the list

$$15 - x = 4$$

$$x = 15 - 4 = 11$$

(Reason: The list is in ascending order, so the smallest number is x and the largest is 15. The range is the largest take away the smallest, and it is given as 4, so x is the only unknown left in that equation.)

Step 2: use the median, which for four numbers is the mean of the middle two

$$\frac{x + y}{2} = 12.5$$

$$x + y = 25$$

(Reason: Four is an even amount, so no single number sits in the middle. The middle two are x and y , and their mean is 12.5. Multiplying both sides by 2 clears the fraction and leaves the sum of the pair.)

Step 3: substitute the value of x to find y

$$11 + y = 25$$

$$y = 25 - 11 = 14$$

(Reason: Step 1 gives $x = 11$, and putting that into $x + y = 25$ leaves a one-step equation in y .)

Step 4: write the finished list and confirm it obeys everything the question said

11, 11, 14, 15

$$11 \leq 11 \leq 14 \leq 15$$

(Reason: The list is still in ascending order, and 11 and 14 are both integers, so nothing the question stated has been broken. This matters here: the median and the range on their own do not pin the letters down, and the order is what decides which value belongs to which letter.)

$$x = 11$$

$$y = 14$$

Verification

- ✓ **Check 1:** Work the median back out of the finished list 11, 11, 14, 15. The middle two numbers are 11 and 14. $\frac{11 + 14}{2} = \frac{25}{2} = 12.5$
- ✓ **Check 2:** Work the range back out of the same list, largest take away smallest. This uses the two numbers Check 1 did not. $15 - 11 = 4$
- ✓ **Check 3:** Test the swap, $x = 14$ and $y = 11$. It gives 14, 14, 11, 15, whose median and range both still come out as 12.5 and 4, so the only thing that rules it out is the ascending order. $11 < 14$, so 14, 14, 11, 15 is not in ascending order

Mark Scheme Breakdown

Step	Mark	Description	Got it?
Both values correct: $x = 11$ and $y = 14$	B2	Full marks for both values. These are B marks, so they are for the values themselves and no working is required; a correct pair with no method shown still scores B2.	✓
Exactly one value correct: $x = 11$ or $y = 14$	B1	Awarded when one of the two values is right and the other is not - for example the range is used correctly to reach $x = 11$ but the median is then treated as the mean of all four numbers, or $y = 14$ is right while x is not. The mark scheme prints this row in brackets beneath the B2, as the partial award.	✓

Step	Mark	Description	Got it?
Special case - the letters the wrong way round: $x = 14$ and $y = 11$	-	SC B1. This row carries no mark of its own; it records what that one specific wrong answer is worth. The error is naming the letters the wrong way round, and it is worth a mark because the arithmetic behind it is sound: 14, 14, 11, 15 has a median of 12.5 and a range of 4, so both stated conditions are met and only the ascending order is broken.	✓

Full marks: 2/2

Question 20 - Exam Solution

Understanding the Question

Given

The universal set
 $\mathcal{E} = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$, so every set here is taken from the numbers 1 to 10
 $A = \{\text{factors of } 6\}$ and
 $B = \{\text{prime numbers}\}$
 C has 4 members, with $A \cap C$ and $B \cap C$ each having 2 members and sharing no member

Find

(a)(i) the members of $A \cup B$ (a)(ii) the members of A' (b) a reason why $A \cap B = \emptyset$ is wrong (c) the 4 members of C

Plan the Solution

- Write out A and B as lists first. Every part of the question is read off those two lists.
- For (a)(i) collect everything that is in either list, writing a repeated member once only.
- For (a)(ii) go through the universal set and keep whatever is missing from A .
- For (b) find the members the two lists share. A set that has a member in it cannot be the empty set.
- For (c) work out where each pair of members of C is allowed to come from, then check the answer against all three conditions.

Worked Solution [5 marks]

Rule - Set notation: $A \cup B$ (union) is everything in A or in B or in both; $A \cap B$ (intersection) is everything in both; A' (complement) is everything in $\mathcal{E}$ that is not in A ; and $\emptyset$ is the set with no members at all.

Step 1: List the members of A

$$6 = 1 \times 6 = 2 \times 3$$

$$A = \{1, 2, 3, 6\}$$

(Reason: (Reason: the factors of 6 are the whole numbers that divide into 6 exactly. The two factor pairs 1×6 and 2×3 give all four of them, and all four are inside the universal set.))

Step 2: List the members of B

$$B = \{2, 3, 5, 7\}$$

(Reason: (Reason: a prime number has exactly two factors, itself and 1. So 1 is not prime, and 4, 6, 8, 9 and 10 all have more than two factors.))

Step 3: (a)(i) Take the union of the two lists

$$A \cup B = \{1, 2, 3, 6\} \cup \{2, 3, 5, 7\}$$

$$A \cup B = \{1, 2, 3, 5, 6, 7\}$$

(Reason: (Reason: the union collects everything that appears in either list. 2 and 3 appear in both lists, but a set never repeats a member, so each is written once.))

Step 4: (a)(ii) Take the complement of A

$$\mathcal{E} = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$$

$$A' = \{4, 5, 7, 8, 9, 10\}$$

(Reason: (Reason: A' is everything in the universal set that is not a factor of 6. Every number in $\mathcal{E}$ is in exactly one of A and A' , so the two lists together must account for all 10 of them.))

Step 5: (b) Work out $A \cap B$

$$A \cap B = \{1, 2, 3, 6\} \cap \{2, 3, 5, 7\}$$

$$A \cap B = \{2, 3\}$$

(Reason: (Reason: 2 and 3 are factors of 6 and they are also prime, so they sit in both sets. The intersection therefore has members in it, and a set with members in it is not the empty set.))

Step 6: (c) Decide where the members of C may come from

$$A \cap B = \{2, 3\}$$

$$A \setminus B = \{1, 6\}$$

$$B \setminus A = \{5, 7\}$$

(Reason: (Reason: if a member of $A \cap C$ were also prime, it would sit in $B \cap C$ as well, and those two sets are told to share no member. So $A \cap C$ cannot use 2 or 3, and by the same argument neither

can $B \cap C$.)

Step 7: (c) List the 4 members of C

$$A \cap C = \{1, 6\}$$

$$B \cap C = \{5, 7\}$$

$$C = \{1, 5, 6, 7\}$$

(Reason: (Reason: only 1 and 6 are left for $A \cap C$ and only 5 and 7 are left for $B \cap C$, and each of those sets needs exactly 2 members, so both are forced. That is already 4 members, which is all the room C has.))

$$(a)(i) A \cup B = \{1, 2, 3, 5, 6, 7\}$$

$$(a)(ii) A' = \{4, 5, 7, 8, 9, 10\}$$

**(b) 2 and 3 are members of both A and B , so $A \cap B = \{2, 3\}$,
which is not empty**

$$(c) C = \{1, 5, 6, 7\}$$

Verification

- ✓ **Check 1:** Count the complement. A has 4 members and the universal set has 10, so A' must have $10 - 4 = 6$ members. 4, 5, 7, 8, 9, 10 is 6 members, and putting A and A' together gives every number from 1 to 10 exactly once
- ✓ **Check 2:** Count the union a different way, using $|A \cup B| = |A| + |B| - |A \cap B|$, which subtracts the shared members so they are not counted twice. $4 + 4 - 2 = 6$, and the list 1, 2, 3, 5, 6, 7 has 6 members
- ✓ **Check 3:** Test $C = \{1, 5, 6, 7\}$ against all three conditions in the question. $A \cap C = \{1, 6\}$ has 2 members, $B \cap C = \{5, 7\}$ has 2 members, those two sets share nothing, and C has 4 members
- ✓ **Check 4:** Check that no other answer works, by testing every set of 4 numbers chosen from 1 to 12 against the same three conditions. Going past 10 also tests whether a number from outside the universal set could be used. Exactly one of the 495 sets passes, and it is $\{1, 5, 6, 7\}$

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a)(i) List the members of	B1	1, 2, 3, 5, 6, 7 - in any order, with no repeats	✓

Step	Mark	Description	Got it?
$A \cup B$			
(a)(ii) List the members of A'	B1	4, 5, 7, 8, 9, 10 - in any order, with no repeats	✓
(b) Explain why the intersection is not empty	B1	For identifying 2, or 3, or 2 and 3, as a member of both A and B , together with an explanation showing the meaning of intersection and of the empty set. Accept equivalent wording, for example that the two sets have a common member or that $A \cap B = \{2, 3\}$. If a common number is quoted, it must be correct.	✓
(c) List the 4 members of set C	B2	1, 5, 6, 7 - in any order. Partial credit: B1 for three correct values with no more than one incorrect, or for four correct values with no more than one incorrect.	✓

Full marks: 5/5

Question 21 - Exam Solution

Understanding the Question

Given

The design is a circle inside a square $ABCD$, and the circle touches the square at E, F, G and H .
 The area of the square is 81 cm^2 , which is a square number.
 The wire has to go all the way round the square and all the way round the circle.

Find

The total length of wire: the perimeter of the square added to the circumference of the circle. The answer is wanted correct to 3 significant figures, so the full decimal is kept until the very last line.

Plan the Solution

- The area of a square is the side multiplied by itself, so square-rooting 81 gives the side.
- Four equal sides then give the perimeter of the square.
- A circle that touches all four sides fits exactly across the square, so its diameter is the same length as a side. That is the link the whole question turns on.
- Use $C = \pi d$ for the circumference, add the two lengths, and round only at the end.

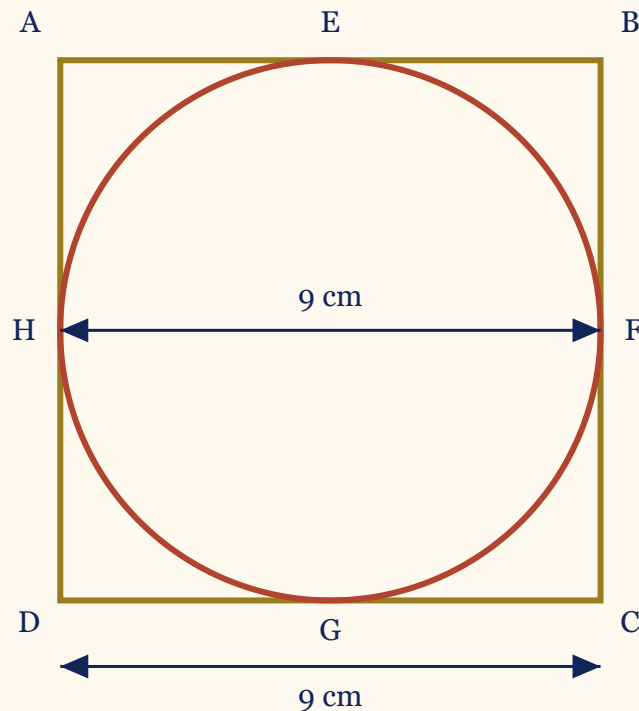
Worked Solution [4 marks]

Rule - Square: $A = s^2$ and $P = 4s$. Circle: $C = \pi d$, and $d = 2r$.

Step 1: Find the length of one side of the square

$$s^2 = 81$$

$$s = \sqrt{81} = 9$$



(Reason: The area of a square is one side multiplied by itself, so the side is the square root of the area. 81 is a square number and $9 \times 9 = 81$, so the side is exactly 9 cm with nothing to round.)

Step 2: Work out the perimeter of the square

$$P = 4 \times 9 = 36$$

(Reason: The wire round the square runs along all four sides, and every side of a square is the same length, so multiply by 4. That is 36 cm of wire before the circle is even considered.)

Step 3: Work out the circumference of the circle

$$d = 9$$

$$C = \pi d$$

$$C = \pi \times 9 = 28.274\dots$$

(Reason: The circle touches all four sides, so it stretches right across the square and its diameter is the same as the side: 9 cm. Keep the decimal running rather than writing 28.3 here, because rounding twice drags the final answer off.)

Step 4: Add the two lengths and round

$$36 + 9\pi = 64.274 \dots$$

$$64.274 \dots \approx 64.3$$

(Reason: One length of wire makes both outlines, so the perimeter and the circumference are added. The first 3 significant figures are 6, 4 and 2; the next digit is 7, so the 2 rounds up to 3.)

64.3 cm

Verification

- ✓ **Check 1:** Work backwards: take the square's perimeter off the total, then divide what is left by π . That should hand back the diameter. $\frac{64.274 \dots - 36}{\pi} = 9$, which is the side of the square, exactly as the inscribed circle requires.
- ✓ **Check 2:** Keep the answer exact rather than decimal, then let the calculator do the whole sum in one go: $36 + 9\pi$. $36 + 9\pi = 64.2743 \dots$, which rounds to 64.3 and sits inside the mark scheme's band of 64.26 to 64.3.
- ✓ **Check 3:** A rough size check, done without a calculator. π is a little over 3, so the circumference is a little over 27 cm. That gives roughly $36 + 27 = 63$ cm, so an answer near 64 cm is the right size. An answer near 50 cm would mean the radius had been used where the diameter belongs, and an answer near 93 cm would mean the side had been used as the radius.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
A method for the length of a side of the square	M1	for $\sqrt{81}$ ($= 9$) or 9 or 9×9 ($= 81$). This may be seen on the diagram rather than in the working.	✓
The perimeter of the square	M1	for 4×9 ($= 36$) oe. The first M mark can be implied by 36.	✓
A correct expression for the circumference of the circle	M1	for using $2\pi r$ or πD , eg $\pi \times 9$ ($= 28.2(743 \dots)$) or 9π . The first M mark can be implied by 28.2(743 $\dots$) rounded or truncated to 1 dp, or by 9π .	✓
The total length of wire	A1	for 64.3. Accept anything from 64.26 to 64.3, which is the band a candidate lands in when the	✓

Step	Mark	Description	Got it?
		circumference is rounded or truncated part way through.	
Note	-	Working not required, so a correct answer scores full marks (unless it comes from obviously incorrect working). This row carries no mark of its own and does not add to the total of four.	✓

Full marks: 4/4

Question 22 - Exam Solution

Understanding the Question

Given

(a) An equation with a fraction on one

side: $\frac{2f}{3} = 4f - 17$

(b) A bracket raised to the power 0:

$(e + 12)^0$, and we are told $e > 0$

(c) One algebraic term divided by

another: $\frac{12a^4h^6}{4ah^2}$

(d) A two term expression to factorise:

$20x^5y + 12x^3y^4$

Find

(a) The value of f , with the algebra

written out - the mark scheme says

working is required. (b) The simplified

value of the power. (c) The quotient

written as a single term, simplified fully.

(d) The expression written as a product,

factorised fully.

Plan the Solution

- (a) The fraction is the awkward part, so remove it first: multiply every term on both sides by 3. Then gather the f terms on one side to reach the form $af = b$, and divide.
- (b) Check the bracket cannot be zero, then apply the zero index law.
- (c) Deal with the numbers and each letter separately: divide the numbers, and subtract the indices of a and of h .
- (d) Build the highest common factor from the numbers and the LOWEST power of each letter, take it outside a bracket, then divide each term by it.

Worked Solution [8 marks]

Rule - Linear equations and index laws: multiply out to clear a fraction, then collect like terms; $\frac{x^m}{x^n} = x^{m-n}$, $x^0 = 1$ for any x that is not zero, and to factorise you take out the highest common factor of every term.

Step 1: (a) Multiply both sides by 3 to clear the fraction

$$\frac{2f}{3} \times 3 = (4f - 17) \times 3$$

$$2f = 12f - 51$$

(Reason: Multiplying by 3 cancels the denominator on the left. On the right BOTH terms inside the bracket are multiplied by 3, so $4f$ becomes $12f$ and 17 becomes 51.)

Step 2: (a) Collect the f terms on one side

$$2f - 12f = -51$$

$$-10f = -51$$

(Reason: Subtracting $12f$ from both sides leaves a two term equation in the form $af = b$, which is what the second method mark is for.)

Step 3: (a) Divide both sides by -10

$$f = \frac{-51}{-10}$$

$$f = \frac{51}{10} = 5.1$$

(Reason: A negative divided by a negative is positive, so $f = \frac{51}{10}$. The mark scheme accepts the equivalent decimal 5.1.)

Step 4: (b) Use the zero index law

$$e > 0 \implies e + 12 > 12$$

$$(e + 12)^0 = 1$$

(Reason: Anything except zero raised to the power 0 equals 1. Because $e > 0$, the bracket is at least 12 and so can never be zero - the answer is 1 whatever e is.)

Step 5: (c) Divide the numbers, and subtract the indices letter by letter

$$\frac{12}{4} = 3$$

$$\frac{a^4}{a} = a^{4-1} = a^3$$

$$\frac{h^6}{h^2} = h^{6-2} = h^4$$

$$\frac{12a^4h^6}{4ah^2} = 3a^3h^4$$

(Reason: A quotient of terms splits into three separate divisions: the numbers, the a powers and the h powers. Dividing powers of the same letter means **SUBTRACTING** the indices, so a has index $4 - 1$ and h has index $6 - 2$.)

Step 6: (d) Build the highest common factor of the two terms

$$20x^5y = 4 \times 5 \times x^3 \times x^2 \times y$$

$$12x^3y^4 = 4 \times 3 \times x^3 \times y \times y^3$$

$$\text{HCF} = 4x^3y$$

(Reason: The largest number that divides both 20 and 12 is 4. For each letter take the **LOWEST** power that appears in both terms: x^3 and y .)

Step 7: (d) Divide each term by the highest common factor and write the bracket

$$\frac{20x^5y}{4x^3y} = 5x^2$$

$$\frac{12x^3y^4}{4x^3y} = 3y^3$$

$$20x^5y + 12x^3y^4 = 4x^3y(5x^2 + 3y^3)$$

(Reason: What is left inside the bracket is each original term divided by the common factor. The bracket $5x^2 + 3y^3$ has no common factor left - 5 and 3 share no factor and the two terms share no letter - so the factorisation is full.)

$$\text{(a)} \quad f = \frac{51}{10} = 5.1$$

$$\text{(b)} \quad 1$$

$$\text{(c)} \quad 3a^3h^4$$

$$\text{(d)} \quad 4x^3y(5x^2 + 3y^3)$$

Verification

✓ **Check 1:** (a) Put $f = 5.1$ back into the original equation and work out each side on its own. $\frac{2 \times 5.1}{3} = \frac{10.2}{3} = 3.4$ and $4 \times 5.1 - 17 = 20.4 - 17 = 3.4$, so the two sides agree.

✓ **Check 2:** (b) Test the rule with a number: taking $e = 1$ makes the bracket 13. $13^0 = 1$, and the same happens for $e = 0.5$ or $e = 100$ - the bracket is never zero, so the value is always 1.

- ✓ **Check 3:** (c) Multiply the answer back by the denominator; it must rebuild the numerator.
 $4ah^2 \times 3a^3h^4 = 12a^4h^6$, which is the term we started with, so the indices are 3 and 4.
- ✓ **Check 4:** (d) Expand the factorised form and compare it with the original expression.
 $4x^3y \times 5x^2 = 20x^5y$ and $4x^3y \times 3y^3 = 12x^3y^4$, which add to give the expression in the question.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a) A correct first step: both sides multiplied by 3 and expanded, e.g. $2f = 12f - 51$ or $2f = -51 + 12f$	M1	Also allowed: the right hand side written as two terms each over 2, e.g. $\frac{f}{3} = 2f - \frac{17}{2}$, or $0.3f = 2f - 8.5$, or $f = 6f - 25.5$. Decimals to 1 decimal place or better are accepted, rounded or truncated.	✓
(a) A correct two term equation in the form $af = b$, e.g. $-10f = -51$ or $10f = 51$ or $5f = \frac{51}{2}$	M1	Follow through is allowed from these equations only: $2f = 12f - 17$, $2f = 4f - 51$ and $6f = 12f - 51$ or equivalent. Decimals to 1 decimal place or better, rounded or truncated.	✓
(a) $f = \frac{51}{10}$ or equivalent, with the algebra shown	A1	Dependent on at least the first method mark. Working is required, so an answer with no algebra scores no accuracy mark. Accept 5.1 as an equivalent.	✓
(b) 1	B1	Independent of the rest of the question. Any bracket that is not zero raised to the power 0 gives 1, and $e > 0$ guarantees the bracket is not zero.	✓
(c) $3a^3h^4$ or equivalent	B2	B1 for a product in the form ka^ph^q where 2 of k , p , q are correct, allowing multiplication signs, e.g. $5a^3h^4$ or $\frac{12a^3h^4}{4}$. Allow $3a^3$, a^3h^4 or $3h^4$ as long as it is not added to any other term.	✓
(d) $4x^3y(5x^2 + 3y^3)$	B2	B1 for any correct factorisation with at least a two term factor outside the bracket, e.g. $2x^3y(10x^2 + 6y^3)$, $x^3y(20x^2 + 12y^3)$, $2x(10x^4y + 6x^2y^4)$, $4y(5x^5 + 3x^3y^3)$ or $4x^3(5x^2y + 3y^4)$. B1 also for the correct highest common factor together with a two term	✓

Step	Mark	Description	Got it?
		expression containing at most one incorrect term, e.g. $4x^3y(5x^2 + \dots)$.	

Full marks: 8/8

Question 23 - Exam Solution

Understanding the Question

Given

One statement about powers,

$$\frac{3^{-2} \times 3^5}{3^{10}} = 3^n.$$

Every power in it has the same base, 3, so the index laws apply straight away.

Find

The value of the index n , which is a whole number here.

Plan the Solution

- Tidy the numerator first: $3^{-2} \times 3^5$ is a multiplication of powers of the same base, so the indices add.
- Then handle the fraction: dividing powers of the same base subtracts the indices.
- That leaves a single power of 3. Compare it with 3^n and read off n .
- A calculator is allowed, so the whole thing can be checked as an ordinary fraction at the end.

Worked Solution [2 marks]

Rule - Index laws for the same base: $a^m \times a^p = a^{m+p}$ and $\frac{a^m}{a^p} = a^{m-p}$.

Step 1: Combine the two powers in the numerator

$$3^{-2} \times 3^5 = 3^{-2+5} = 3^3$$

(Reason: The base is 3 on both, so the two powers combine into a single power of 3 and only the indices are worked with. A negative index is used exactly like any other index here.)

Step 2: Divide by the denominator

$$\frac{3^3}{3^{10}} = 3^{3-10} = 3^{-7}$$

(Reason: Dividing powers of the same base subtracts the index of the denominator from the index of the numerator. The denominator index 10 is the larger, so the result is a negative index.)

Step 3: Compare the single power with 3^n

$$3^{-7} = 3^n$$

$$n = -7$$

(Reason: Two powers of the same base are equal only when their indices are equal, so the index on the left is the value of n .)

$$n = -7$$

Verification

✓ **Check 1:** Work the left-hand side out as an ordinary number instead of using any index law. The numerator is $3^{-2} \times 3^5 = 27$ and the denominator is $3^{10} = 59049$, so the fraction is $\frac{27}{59049} = \frac{1}{2187}$. $3^{-7} = \frac{1}{3^7} = \frac{1}{2187}$, the same number, so $n = -7$ is right.

✓ **Check 2:** Take the two steps in the other order. Divide first: $\frac{3^{-2}}{3^{10}} = 3^{-12}$, then multiply by 3^5 . $3^{-12} \times 3^5 = 3^{-12+5} = 3^{-7}$, so $n = -7$ again, from a different order of working.

✓ **Check 3:** A sign sanity check. Adding the indices above the line gives $-2 + 5 = 3$, and the index below the line is 10, which is bigger. A smaller index on top than underneath must leave a negative index, and -7 is negative. A positive answer such as 7 could be rejected on sight.

Mark Scheme Breakdown

Step	Mark	Description	Got it?
A correct application of an index rule as a first step, for example 3^3 or $(3^{-2}) \times 3^{-5}$ or $\frac{3^3}{3^{10}}$ or $\frac{(3^5)}{3^{12}}$ or $\frac{(3^{-2})}{3^5}$ or $3^{-12}(\times 3^5)$ or equivalent. A correct calculation for n also earns it: $-2 + 5 - 10$ or $-12 + 5$ or $3 - 10$ or equivalent.	M1	Method: one index law applied correctly to the same base, or the index arithmetic written out in full. Either route into the question scores this mark.	✓
$n = -7$	A1	Accuracy: the value -7 . Allow 3^{-7} as the answer.	✓

Step	Mark	Description	Got it?
Working is not required on this question, so a correct answer alone scores full marks, unless it follows obviously incorrect working.	Note	Guidance row, carrying no mark of its own. It tells the marker that an unsupported –7 is worth the full 2 marks.	✓

Full marks: 2/2

Question 24 - Exam Solution

Understanding the Question

Given

Every normal price in the sale is reduced by 17%
The sale price of the washing machine is 6225 rupees

Find

The normal price of the washing machine, in rupees

Plan the Solution

- The normal price is the whole amount, so it counts as 100%. The reduction is taken off the NORMAL price, not off the sale price - that is the whole difficulty of the question.
- Work out what percentage of the normal price the shopper actually pays, and write that percentage as a decimal multiplier.
- The sale price is the normal price multiplied by that decimal, so divide the sale price by it to get back to the normal price.
- Check by taking 17% off the answer and confirming that 6225 comes back.

Worked Solution [3 marks]

Rule - Reverse percentage: a reduction of $r\%$ leaves $(100 - r)\%$ of the original price, so

$$\text{normal price} = \frac{\text{sale price}}{\text{multiplier}}$$
 where the multiplier is that remaining percentage written as a decimal. You divide by the multiplier - you never add the percentage back on.

Step 1: Work out the percentage that is left

$$100\% - 17\% = 83\%$$

$$83\% = \frac{83}{100} = 0.83$$

(Reason: (Reason: the normal price is the whole amount, 100%. Taking 17% off it leaves 83% of the normal price, and 83% written as a decimal is 0.83.))

Step 2: Write the sale price in terms of the normal price

$$\text{normal price} \times 0.83 = 6225$$

(Reason: (Reason: 83% of the normal price is what the shopper pays, and what the shopper pays is 6225 rupees, so those two amounts are equal.))

Step 3: Divide to undo the multiplication

$$\text{normal price} = \frac{6225}{0.83} = 7500$$

(Reason: (Reason: the normal price was multiplied by 0.83 to give the sale price, so dividing the sale price by 0.83 takes it back to the normal price. Dividing by a number smaller than 1 makes the amount bigger, which is what a reversed reduction should do.))

Step 4: The same answer from 1% of the normal price

$$1\% \text{ of the normal price} = \frac{6225}{83} = 75$$

$$100\% \text{ of the normal price} = 75 \times 100 = 7500$$

(Reason: (Reason: 6225 rupees is 83% of the normal price, so dividing it by 83 gives 1% of the normal price. Multiplying that by 100 rebuilds the full 100%. The mark scheme allows this route as well, and it gives the same answer.))

7500 rupees

Verification

- ✓ **Check 1:** Put the answer through the sale. Multiply it by 0.83 and see whether the sale price comes back. $7500 \times 0.83 = 6225$, which is exactly the sale price the question gives
- ✓ **Check 2:** Work the reduction out as a percentage, which is a different calculation from Check 1: subtract to find how much came off, then compare that with the normal price.
 $7500 - 6225 = 1275$ and $\frac{1275}{7500} = 0.17$, so the reduction really is 17% of the normal price
- ✓ **Check 3:** Test the tempting wrong method, which is to add 17% back onto the sale price. If that worked, 17% of the sale price would equal the amount that came off.
 $6225 \times 0.17 = 1058.25$, but the amount that came off is 1275, so
 $6225 + 1058.25 = 7283.25$ is not the normal price

Mark Scheme Breakdown

Step	Mark	Description	Got it?
Find the percentage, or the multiplier, that is left after the 17% reduction	M1	For $1 - 0.17$ or 0.83 or $\frac{83}{100}$, or for $100(\%) - 17(\%)$ or $83(\%)$, or for $\frac{6225}{83} (= 75)$ oe	✓
Divide the sale price by that multiplier	M1	For $\frac{6225}{0.83}$ or $\frac{6225}{83} \times 100$ or $\frac{6225 \times 100}{83}$ oe, or for 75×100 . The official scheme writes the multiplier in quotation marks, which means the candidate's own value from the first mark is followed through.	✓
State the normal price	A1	7500. Working is not required, so a correct answer scores full marks unless it comes from obviously incorrect working.	✓

Full marks: 3/3

Question 25 - Exam Solution

Understanding the Question

Given

A number written in standard form, 6.04×10^5 .

An ordinary number, 0.000 07.

The fraction $\frac{7.6 \times 10^{10}}{4 \times 10^5 - 2 \times 10^4}$, whose denominator is a subtraction.

Find

(a) The same value written as an ordinary number. (b) The same value written in standard form. (c) The value of the fraction, in standard form.

Plan the Solution

- Parts (a) and (b) are one move each: multiplying by 10^5 shifts the digits left, dividing by 10^5 shifts them right.
- Part (c) has an order to it. The denominator $4 \times 10^5 - 2 \times 10^4$ is a subtraction, so it must be worked out as one number before any dividing happens.

- Write both terms as ordinary numbers first, because 10^5 and 10^4 are different powers and cannot be subtracted directly.
- Put the denominator back into standard form, then divide the front numbers and subtract the indices.
- Finish by checking the front number of the answer is at least 1 and less than 10.

Worked Solution [4 marks]

Rule - Standard form: every number is written $a \times 10^n$ where $1 \leq a < 10$ and n is a whole number. To divide two numbers in standard form, divide the values of a and

subtract the indices: $\frac{a \times 10^m}{b \times 10^n} = \frac{a}{b} \times 10^{m-n}$.

Step 1: Part (a) - multiply 6.04 by 10^5

$$10^5 = 100\,000$$

$$6.04 \times 100\,000 = 604\,000$$

(Reason: Multiplying by 10^5 moves every digit 5 places to the left, which is the same as moving the decimal point in 6.04 five places to the right. Zeros fill the empty places.)

Step 2: Part (b) - count the places in 0.000 07

$$0.000\,07 = \frac{7}{100\,000}$$

$$\frac{7}{100\,000} = \frac{7}{10^5} = 7 \times 10^{-5}$$

(Reason: Standard form needs a front number with $1 \leq a < 10$, so the 7 must sit in the units place. Getting it there means moving the point 5 places, and because the number is smaller than 1 the index is negative.)

Step 3: Part (c) - work out the denominator first

$$4 \times 10^5 = 400\,000$$

$$2 \times 10^4 = 20\,000$$

$$400\,000 - 20\,000 = 380\,000$$

(Reason: The bottom of the fraction is a subtraction, and a fraction bar means the whole of the bottom is divided into the whole of the top. 10^5 and 10^4 are not the same power, so the two terms are turned into ordinary numbers before subtracting.)

Step 4: Part (c) - put the denominator in standard form and divide

$$380\,000 = 3.8 \times 10^5$$

$$\frac{7.6 \times 10^{10}}{3.8 \times 10^5} = \frac{7.6}{3.8} \times 10^{10-5}$$

$$= 2 \times 10^5$$

(Reason: Divide the front numbers and subtract the indices: $\frac{7.6}{3.8} = 2$ and $10 - 5 = 5$. Since $1 \leq 2 < 10$, the answer is already in standard form and needs no adjusting.)

$$(a) 604\,000$$

$$(b) 7 \times 10^{-5}$$

$$(c) 2 \times 10^5$$

Verification

- ✓ **Check 1:** Part (a) backwards: count how many places the point in 604 000 has to move to leave a front number between 1 and 10. $604\,000 = 6.04 \times 10^5$
- ✓ **Check 2:** Part (b) backwards: 10^{-5} means one part in 100 000, so the answer should turn back into the number given. $\frac{7}{100\,000} = 0.000\,07$
- ✓ **Check 3:** Part (c) backwards: multiplying the answer by the denominator must rebuild the numerator. $2 \times 10^5 \times 3.8 \times 10^5 = 7.6 \times 10^{10}$
- ✓ **Check 4:** Part (c) a second way, with ordinary numbers only and no index laws at all.

$$\frac{76\,000\,000\,000}{380\,000} = 200\,000 = 2 \times 10^5$$

Mark Scheme Breakdown

Step	Mark	Description	Got it?
(a) Write 6.04×10^5 as an ordinary number	B1	Answer of 604 000. No working is needed for this mark.	✓
(b) Write 0.000 07 in standard form	B1	Answer of 7×10^{-5} . The negative index is essential; 7×10^5 earns nothing.	✓
(c) Simplify the denominator	M1	For 380 000 or 3.8×10^5 or 38×10^4 or equivalent seen anywhere.	✓
(c) Divide and give the answer in standard form	A1	Answer of 2×10^5 . Accept 2.0×10^5 or 2.00×10^5 and so on. Accept a dot or a comma in place of the multiplication sign, for example 2.10^5 .	✓

Step	Mark	Description	Got it?
(c) Special case - the division is right but the form is not	SC B1	Awarded only when no other mark is earned in part (c), for a final answer of 200 000 or 20×10^4 or 0.2×10^6 or equivalent, or 2×10^n with $n \neq 5$. The student has divided correctly and then written the result in a form that is not standard form. It is not awarded when the denominator was simplified incorrectly.	✓
(c) Note on working	(no mark)	Working is not required in part (c), so a correct answer on its own scores both marks, unless it clearly follows from incorrect working.	✓

Full marks: 4/4

Question 26 - Exam Solution

Understanding the Question

Given

$ED = 23$ cm, $FE = 4.7$ cm, and the angles at E and D are right angles
 $AB = 11$ cm and $BC = 5$ cm
 Angle $BCF = 30^\circ$
 AB , FC and ED are parallel, so the hexagon is a rectangle with a trapezium on top

Find

The area of hexagon $ABCDEF$, in cm^2

Plan the Solution

- Cut the hexagon along the dotted line FC into rectangle $FEDC$ and trapezium $ABCF$.
- Use the right angles at E and D to say that $FEDC$ is a rectangle, so $FC = ED = 23$ cm.
- The trapezium's own height is not given, so get it from the 5 cm side and the 30° angle at C .
- Work out the two areas separately, then add them.

Worked Solution [5 marks]

Rectangle: area = length $\times$ width. Trapezium: area = $\frac{1}{2}(a + b)h$, where a and b are the parallel sides and h is the perpendicular distance between them. In a right-angled triangle, $\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}}$.

Step 1: cut the hexagon along FC

$$ABCDEF = FEDC + ABCF$$

(Reason: The hexagon has no area formula of its own, but the two pieces do. FC is parallel to ED and the angles at E and D are right angles, so $FEDC$ is a rectangle; AB is parallel to FC , so $ABCF$ is a trapezium.)

Step 2: the area of rectangle $FEDC$

$$23 \times 4.7 = 108.1$$

(Reason: Opposite sides of a rectangle are equal, so $FC = ED = 23$ cm and $DC = FE = 4.7$ cm. The rectangle is therefore 23 cm by 4.7 cm.)

Step 3: the perpendicular height of trapezium $ABCF$

$$\sin 30^\circ = \frac{h}{5}$$

$$h = 5 \sin 30^\circ$$

$$5 \times 0.5 = 2.5$$

(Reason: Drop a perpendicular from B onto FC . That makes a right-angled triangle whose hypotenuse is $BC = 5$ cm, with the 30° angle at C . The height is the side opposite that angle, so it is the sine that is needed, and the height is 2.5 cm. The 5 cm is the slope, not the height.)

Step 4: the area of trapezium $ABCF$

$$\text{area} = \frac{1}{2}(AB + FC) \times h$$

$$\frac{1}{2} \times (11 + 23) \times 2.5 = 42.5$$

(Reason: The two parallel sides are $AB = 11$ cm and $FC = 23$ cm, and h is the perpendicular distance between them found in Step 3.)

Step 5: add the two areas

$$108.1 + 42.5 = 150.6$$

(Reason: The rectangle and the trapezium meet along FC and do not overlap, so their areas simply add to give the area of the hexagon. The units are cm^2 because an area is being measured.)

$$150.6 \text{ cm}^2$$

Verification

- ✓ **Check 1:** Build the shape the opposite way round. The hexagon sits inside a rectangle 23 cm by $4.7 + 2.5 = 7.2$ cm, and what has to come off are the two corner triangles above FC . Their bases add to $23 - 11 = 12$ cm and both have height 2.5 cm.
- $23 \times 7.2 = 165.6$ and $\frac{1}{2} \times 12 \times 2.5 = 15$, so the hexagon is $165.6 - 15 = 150.6$
- ✓ **Check 2:** Do the trapezium without its formula. Split $ABCF$ into a parallelogram 11 cm wide and a triangle of base 12 cm, both of height 2.5 cm. $11 \times 2.5 = 27.5$ and $\frac{1}{2} \times 12 \times 2.5 = 15$, so the trapezium is $27.5 + 15 = 42.5$ and the hexagon is $108.1 + 42.5 = 150.6$
- ✓ **Check 3:** Get the height without using sine at all. The horizontal step from B across to C is $5 \cos 30^\circ \approx 4.33$, and squaring it gives exactly 18.75. Pythagoras in the same right-angled triangle then gives the height. $5^2 - 18.75 = 6.25$ and $2.5^2 = 6.25$, so the height really is 2.5 cm

Mark Scheme Breakdown

Step	Mark	Description	Got it?
The area of the rectangle: $23 \times 4.7 = 108.1$ oe	B1	Awarded whatever else happens in the question. It may be embedded in a single calculation for the whole shape, such as $23 \times (4.7 + 2.5) = 165.6$.	✓
A correct method for the height of the trapezium: $\sin 30^\circ = \frac{x}{5}$ oe, where x is that height	M1	The sine rule form $\frac{x}{\sin 30^\circ} = \frac{5}{\sin 90^\circ}$ scores this too, as does the Pythagoras route $5 \cos 30^\circ \approx 4.33$ together with $x^2 = 5^2 - (5 \cos 30^\circ)^2$.	✓
The height itself: $x = 5 \sin 30^\circ = 2.5$ oe	M1	Or the same value from the other route, $x = \sqrt{5^2 - (5 \cos 30^\circ)^2} = 2.5$.	✓
A correct method for the area of the trapezium, or for the whole shape:	M1	Any correct complete method earns it, for example $(11 \times 2.5) + (\frac{1}{2} \times 12 \times 2.5) = 42.5$, or the	✓

Step	Mark	Description	Got it?
$\frac{1}{2} \times (11 + 23) \times$ $2.5 = 42.5$ oe		whole shape at once as $165.6 - 15 = 150.6$. The candidate's own height carries through.	
Working required. 150.6	A1	Not awarded without at least one method mark. Accept anything which rounds to 150.6; allow 151; accept $\frac{753}{5}$.	✓

Full marks: 5/5

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