



BRITISH LEARNING CENTRE

PEARSON EDEXCEL INTERNATIONAL GCSE · 4MA1

Mathematics

Geometry & Measures

Fourteen units covering the geometry and measures content of Section 4 of the Pearson Edexcel International GCSE Mathematics A (4MA1) specification, for Foundation and Higher tiers (trigonometry and Pythagoras are in a separate book). Each unit has notes, worked examples, practice and exam-style questions with mark schemes.

Name:

Key knowledge · Practice · Exam-style questions · Mark schemes

How to use this workbook

1

Key knowledge

Read the notes, worked examples and common mistakes.

2

Practice

Build the skill on Sheet A.

3

Exam-style

Answer exam-style questions on Sheet B. Marks are shown in [].

4

Check & reflect

Mark your work with the mark scheme, then colour the tracker.

My progress tracker

Colour each row: **Red** = not yet · **Amber** = nearly · **Green** = secure.

#	Spec ref	Topic · I can...	R	A	G
1	4.1 Foundation & Higher	Angles, lines and triangles I can find missing angles at points, on lines, in triangles and with parallel lines, giving reasons.			
2	4.2 Foundation & Higher	Polygons I can find interior and exterior angles of polygons and use them to solve problems.			
3	4.2, 4.3 Foundation	Symmetry and quadrilaterals I can recognise line and rotational symmetry and use the properties of special quadrilaterals.			
4	4.4 Foundation & Higher	Measures and unit conversions I can convert between metric units, including units of area and volume (Higher).			
5	4.1, 4.4 Foundation & Higher	Bearings and scale drawings I can use three-figure bearings, map scales and scale drawings.			
6	4.5 Foundation & Higher	Constructions I can measure and draw accurately and construct bisectors, perpendiculars, angles and triangles.			
7	4.9 Foundation	Perimeter and area I can find perimeters and areas of triangles, quadrilaterals and compound shapes.			
8	4.9 Foundation & Higher	Circles, arcs and sectors I can find circumferences and areas of circles and (Higher) arc lengths, sectors and segments.			
9	4.10 Foundation & Higher	Prisms and cylinders I can find the volume and surface area of cuboids, prisms and cylinders.			
10	4.10 Higher	Pyramids, cones and spheres I can find volumes and surface areas of pyramids, cones, spheres, frustums and composite solids.			
11	4.11 Foundation & Higher	Similar shapes I can use scale factors in similar shapes, including (Higher) areas and volumes of similar figures.			
12	4.6 Foundation & Higher	Circle properties I can use the properties of tangents and chords to find angles and lengths in circles.			
13	4.6, 4.7 Higher	Circle theorems I can use the circle theorems and the intersecting chord properties, giving reasons.			
14	4.7 Higher	Congruence and geometrical proof I can prove that triangles are congruent and write geometrical proofs with reasons.			



CHECK

Starting point check

Starting point check

Name _____ Date _____ Score _____ / 12

Answer as many questions as you can. This shows what you already know.

Find x.

1

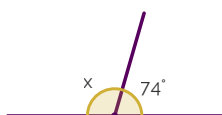


Diagram NOT accurately drawn

Answer $x = \dots\dots$

Find x.

2

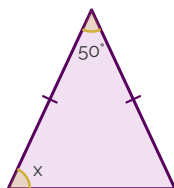


Diagram NOT accurately drawn

Answer $x = \dots\dots$

3

Work out the sum of the interior angles of a hexagon.

Answer $\dots\dots^\circ$

4

How many lines of symmetry does a rectangle have?

Answer $\dots\dots$

5

Change 3.2 km to metres.

Answer $\dots\dots$ m

6

Write down the three-figure bearing of due South.

Answer $\dots\dots^\circ$

7

Find the area of a parallelogram with base 7 cm and height 4 cm.

Answer $\dots\dots$ cm²

8

Find the area of a trapezium with parallel sides 3 cm and 7 cm and height 4 cm.

Answer $\dots\dots$ cm²

9

Find the circumference of a circle with diameter 10 cm (3 s.f.).

Answer $\dots\dots$ cm

10

Find the volume of a cylinder with radius 3 cm and height 5 cm (3 s.f.).

Answer $\dots\dots$ cm³

11

A length of 4 cm is enlarged to 10 cm. Write down the scale factor.

Answer $\dots\dots$

12

What is the name of a straight line that touches a circle at exactly one point?

Answer $\dots\dots\dots$

1

UNIT 1 · KEY KNOWLEDGE

Angles, lines and triangles

I can... find missing angles at points, on lines, in triangles and with parallel lines, giving reasons.

Spec ref: 4.1 · Foundation & Higher

When lines cross, the angles they make follow fixed rules. In Edexcel questions you are often told to **give reasons**: each reason must be a full angle fact, such as "alternate angles are equal".

Key points

- Angles on a straight line sum to 180° . Angles at a point sum to 360° . Vertically opposite angles are equal.
- With parallel lines: alternate angles are equal; corresponding angles are equal; co-interior (allied) angles sum to 180° .
- Angles in a triangle sum to 180° . The exterior angle of a triangle equals the sum of the two interior opposite angles.

Key words

alternate

corresponding

co-interior

vertically opposite

exterior angle

Worked example

AB is parallel to CD. Find the size of angle x. Give a reason for your answer.

Angle x and the angle of 110° lie between the parallel lines, on opposite sides of the transversal.

$x = 110^\circ$ because alternate angles are equal.

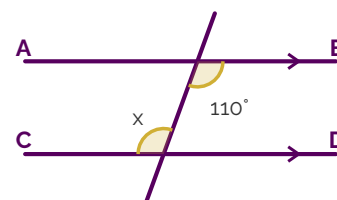


Diagram NOT accurately drawn

Common mistakes

- Writing "Z angles" or "F angles". Use the words alternate and corresponding.
- Giving a reason that does not match the step, e.g. quoting the triangle rule for angles on a line.

Exam tip: Mark each angle you find on the diagram as you go. It helps you see the next step.

Work out the value of x in each diagram. Give a reason.

1

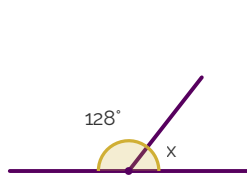


Diagram NOT accurately drawn

Answer $x = \dots\dots$

2

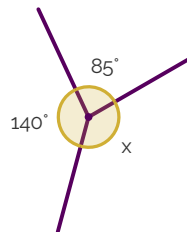


Diagram NOT accurately drawn

Answer $x = \dots\dots$

3

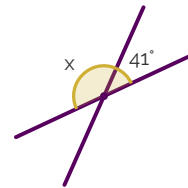


Diagram NOT accurately drawn

Answer $x = \dots\dots$

4

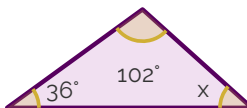


Diagram NOT accurately drawn

Answer $x = \dots\dots$

5

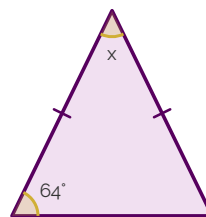


Diagram NOT accurately drawn

Answer $x = \dots\dots$

6

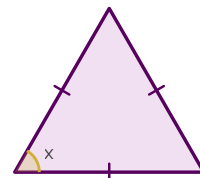


Diagram NOT accurately drawn

Answer $x = \dots\dots$

7

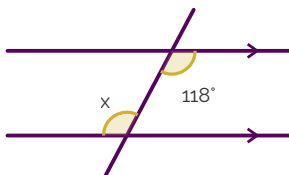


Diagram NOT accurately drawn

Answer $x = \dots\dots$

8

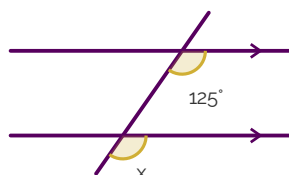


Diagram NOT accurately drawn

Answer $x = \dots\dots$

9

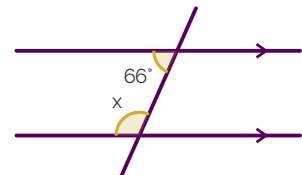


Diagram NOT accurately drawn

Answer $x = \dots\dots$

10

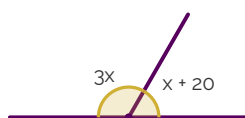


Diagram NOT accurately drawn

Answer $x = \dots\dots$

11

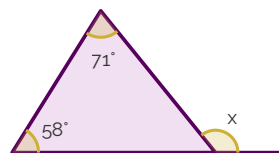


Diagram NOT accurately drawn

Answer $x = \dots\dots$

12

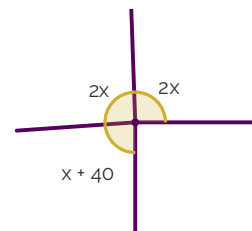


Diagram NOT accurately drawn

Answer $x = \dots\dots$

The unmarked angle is a right angle.

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 AB is parallel to CD.

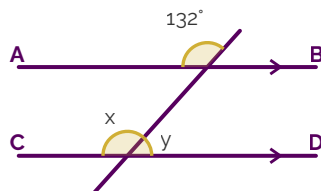


Diagram NOT accurately drawn

- (a) Find the size of angle x . Give a reason for your answer.

[2]

Answer $x = \dots\dots\dots^\circ$

- (b) Find the size of angle y . Give a reason for your answer.

[2]

Answer $y = \dots\dots\dots^\circ$

- (c) Write down the size of the angle that is vertically opposite angle y .

[1]

Answer $\dots\dots\dots^\circ$

- 2 PQR is an isosceles triangle with $PQ = PR$. Angle $QPR = 38^\circ$. The line ST passes through P and is parallel to QR.

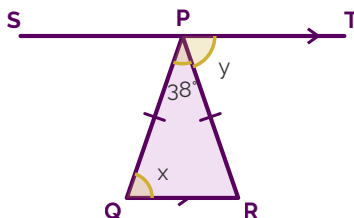


Diagram NOT accurately drawn

- (a) Work out the size of angle x .

[2]

Answer $x = \dots\dots\dots^\circ$

- (b) Work out the size of angle y . Give a reason for your answer.

[2]

Answer $y = \dots\dots\dots^\circ$

- (c) Work out the size of angle SPQ.

[1]

Answer $\dots\dots\dots^\circ$

3 The angles of a triangle are $(x + 10)^\circ$, $2x^\circ$ and $(3x - 40)^\circ$.

(a) Work out the value of x .

[3]

Answer $x = \dots\dots$

(b) Write down the size of the largest angle.

[1]

Answer $\dots\dots^\circ$

(c) What type of triangle is it? Give a reason.

[1]

4 Two straight lines cross. Two vertically opposite angles are $(4y - 15)^\circ$ and $(2y + 35)^\circ$.

(a) Work out the value of y .

[2]

Answer $y = \dots\dots$

(b) Work out the size of each of the other two angles.

[2]

Answer $\dots\dots^\circ$

5 A straight line crosses two other lines. Two co-interior angles are 67° and 112° .

(a) Are the two lines parallel? Give a reason for your answer.

[2]

(b) The 112° angle is kept fixed. What would the other angle need to be for the lines to be parallel?

[1]

Answer $\dots\dots^\circ$

6 *Higher.* Triangle ABC has side BC extended to D. Prove that angle ACD = angle BAC + angle ABC. Give a reason for each step.

[3]

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Polygons

I can... find interior and exterior angles of polygons and use them to solve problems.

Spec ref: 4.2 · Foundation & Higher

A **polygon** is a closed shape with straight sides. Any polygon can be divided into triangles from one vertex, which gives the angle sum. A **regular** polygon has equal sides and equal angles, so you can divide to find each angle.

Key points

- Sum of interior angles of an n -sided polygon = $180(n - 2)^\circ$.
- Exterior angles of any polygon sum to 360° . Interior angle + exterior angle = 180° .
- Regular polygon: each exterior angle = $360^\circ \div n$.

Key words

polygon

regular

interior angle

exterior angle

nonagon

Worked example 1

Work out the size of each interior angle of a regular nonagon (9 sides).

$$\text{Exterior angle} = 360 \div 9 = 40^\circ$$

$$\text{Interior angle} = 180 - 40 = \mathbf{140^\circ}$$

Worked example 2

Each interior angle of a regular polygon is 165° . How many sides does it have?

$$\text{Exterior angle} = 180 - 165 = 15^\circ$$

$$n = 360 \div 15 = \mathbf{24}$$

Common mistakes

- Using $180n$ instead of $180(n - 2)$.
- Forgetting that the 360° rule is for exterior angles, not interior angles.

Exam tip: Learn the names: pentagon 5, hexagon 6, heptagon 7, octagon 8, nonagon 9, decagon 10.

Answer each question. Show your working where it helps.

1 Sum of the interior angles of an octagon

2 Sum of the interior angles of a nonagon

3 Sum of the interior angles of a 12-sided polygon

4 Exterior angle of a regular pentagon

5 Exterior angle of a regular decagon

6 Interior angle of a regular pentagon

7 Interior angle of a regular nonagon

8 Interior angle of a regular 20-sided polygon

9 Regular polygon, exterior angle 20° . Number of sides?

10 Regular polygon, interior angle 150° . Number of sides?

11 Regular polygon, interior angle 135° . Number of sides?

12 A hexagon has angles 110° , 125° , 130° , 95° , 140° and x . Find x .

13 A quadrilateral has angles x , $2x$, $3x$ and $4x$. Find x .

14 A rhombus has an angle of 72° . Find the size of the obtuse angles.

15 The interior angles of a polygon sum to 2520° . Number of sides?

16 Can a regular polygon have an interior angle of 130° ? (yes/no)

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 The diagram shows a regular octagon and a square that share a side.

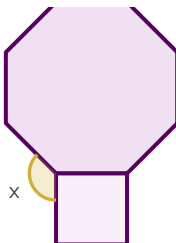


Diagram NOT accurately drawn

- (a) Work out the size of angle x . [3]

Answer $x = \dots\dots\dots^\circ$

- (b) Explain why squares and regular octagons can fit together around a point with no gaps. [1]

- 2 The diagram shows a hexagon.

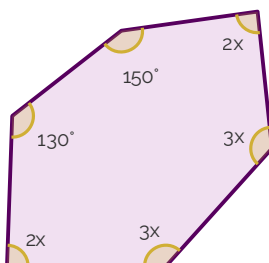


Diagram NOT accurately drawn

- (a) Work out the value of x . [3]

Answer $x = \dots\dots\dots$

- (b) Work out the size of the smallest angle. [1]

Answer $\dots\dots\dots^\circ$

- 3 ABCDE is a regular pentagon.

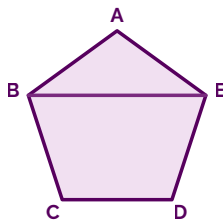


Diagram NOT accurately drawn

- (a) Work out the size of angle ABE. Give reasons. [2]

Answer°

- (b) Work out the size of angle CBE. [1]

Answer°

- (c) Show that BE is parallel to CD. [2]

- 4 Each interior angle of a regular polygon is 8 times the size of each exterior angle.

- (a) Work out the number of sides of the polygon. [3]

Answer

- (b) Work out the sum of the interior angles of the polygon. [2]

Answer°

- 5 *Higher.* Regular polygon A has n sides. Regular polygon B has $2n$ sides. Each exterior angle of A is 18° larger than each exterior angle of B. Work out the value of n . [3]

Answer $n =$

- 6 ABCD is a kite. Angle $A = 3y^\circ$, angle $C = (y + 20)^\circ$ and angles B and D are both $(2y + 10)^\circ$.

- (a) Work out the value of y . [3]

Answer $y =$

- (b) Show that the kite has two right angles. [1]

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Symmetry and quadrilaterals

I can... recognise line and rotational symmetry and use the properties of special quadrilaterals.

Spec ref: 4.2, 4.3 · Foundation

A shape has **line symmetry** if it can be folded so that one half fits exactly on the other. The **order of rotational symmetry** is the number of times a shape looks the same in one full turn. Special quadrilaterals are defined by their sides, angles, diagonals and symmetry.

Key points

- Square: 4 lines, order 4. Rectangle: 2 lines, order 2. Rhombus: 2 lines, order 2.
- Parallelogram: no lines, order 2. Kite and isosceles trapezium: 1 line, order 1.
- Diagonals of a rhombus and a kite cross at 90° . Diagonals of a rectangle are equal.

Key words

line symmetry

rotational symmetry

order

rhombus

kite

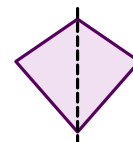
diagonal

Worked example

Describe the symmetry of a kite.

One line of symmetry: the diagonal through the two vertices between the pairs of equal sides.

Rotational symmetry of **order 1** (it only looks the same after a full turn).



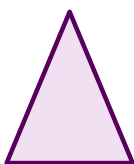
Common mistakes

- Saying a parallelogram has 2 lines of symmetry. It has none.
- Giving order 0 for a shape with no rotational symmetry. The answer is order 1.

Exam tip: Use tracing paper in the exam if it is allowed: trace, then fold or turn it.

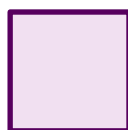
Questions 1–6: write the number of lines of symmetry and the order of rotational symmetry.

1



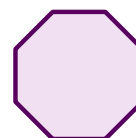
Answer lines order

2



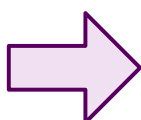
Answer lines order

3



Answer lines order

4



Answer lines order

5



Answer lines order

6



Answer lines order

7

Diagonals equal and
cross at 90° : a
_____.

8

Diagonals bisect each
other, not equal, not at
 90° : a _____.

9

One pair of equal
opposite angles,
diagonals at 90° : a
_____.

10

A trapezium with one
line of symmetry is an

trapezium.

11

Order of rotational
symmetry of a
regular decagon


12

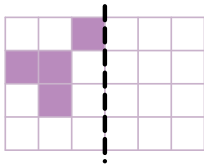
Lines of symmetry of
an equilateral
triangle 

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

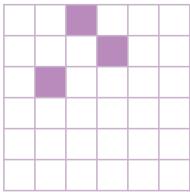
Answer all questions. Show your working. Marks are shown in brackets.

1 Shading patterns.

(a) Shade **four** more squares on the first grid so that the dashed line is a line of symmetry. [2]



(b) Shade **three** more squares on the second grid so that the pattern has rotational symmetry of order 2. [2]

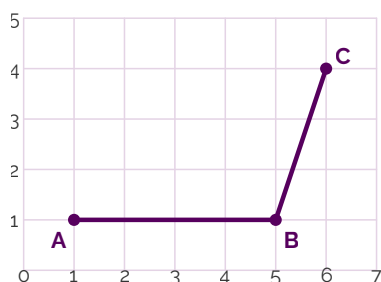


2 Complete the table. Write the number of lines of symmetry and the order of rotational symmetry.

Shape	Lines of symmetry	Order of rotational symmetry
Rhombus		
Kite		
Parallelogram		
Isosceles trapezium		
Regular hexagon		
Equilateral triangle		

(a) Complete the table. [6]

- 3 The points A(1, 1), B(5, 1) and C(6, 4) are plotted on the grid.



- (a) ABCD is a parallelogram. Write down the coordinates of D. [2]

Answer (..... ,)

- (b) Write down the order of rotational symmetry of the parallelogram. [1]

Answer

- (c) How many lines of symmetry does the parallelogram have? [1]

Answer

- 4 Write down the name of each quadrilateral.

Description	Name
4 lines of symmetry	
2 lines of symmetry and 4 right angles	
Diagonals cross at 90° and rotational symmetry of order 2	
Exactly 1 line of symmetry and diagonals that cross at 90°	
No lines of symmetry and rotational symmetry of order 2	

- (a) Complete the table. [5]

- 5 Angles in special quadrilaterals.

- (a) A rhombus has one angle of 54° . Work out the sizes of the other three angles. [2]

Answer $^\circ$, $^\circ$, $^\circ$

- (b) A kite has two equal angles of 112° . Its third angle is 48° . Work out the fourth angle. [2]

Answer $^\circ$

- 6 Reasoning about symmetry.

- (a) Ella says, "Every quadrilateral with two lines of symmetry is a rectangle." Give an example to show that Ella is wrong. [1]

- (b) A shape has rotational symmetry of order 3. Write down the smallest possible number of lines of symmetry it can have. [1]

Answer

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Measures and unit conversions

I can... convert between metric units, including units of area and volume (Higher).

Spec ref: 4.4 · Foundation & Higher

Metric units go up in steps of 10, 100 or 1000. To change to a **smaller** unit, multiply; to change to a **larger** unit, divide. Area and volume units need the factor squared or cubed (Higher).

Key points

- 1 cm = 10 mm; 1 m = 100 cm; 1 km = 1000 m. 1 kg = 1000 g; 1 tonne = 1000 kg; 1 litre = 1000 ml.
- 1 litre = 1000 cm³, so 1 ml = 1 cm³; 1 m³ = 1000 litres.
- *Higher:* 1 m² = 10 000 cm²; 1 m³ = 1 000 000 cm³; 1 km² = 1 000 000 m².

Key words

metric

capacity

mass

litre

conversion

Worked example 1

A jug holds 1.5 litres. How many 180 ml glasses can be filled completely?

1.5 litres = 1500 ml

1500 ÷ 180 = 8.33..., so **8 glasses** (60 ml is left over)

Worked example 2 (Higher)

Change 0.6 m³ to cm³.

1 m³ = 100 × 100 × 100 = 1 000 000 cm³

0.6 × 1 000 000 = **600 000 cm³**

Common mistakes

- Rounding up when the question asks how many can be filled **completely**.
- Using × 100 for cm² to mm²: it is × 100 (10 × 10), but cm³ to mm³ is × 1000.

Exam tip: Write the conversion you are using (for example 1 m = 100 cm) before you calculate.

Fill in each box. Questions 10–18 are Higher.

1 $5.6 \text{ cm} = \boxed{} \text{ mm}$

2 $0.72 \text{ m} = \boxed{} \text{ cm}$

3 $4250 \text{ m} = \boxed{} \text{ km}$

4 $3.05 \text{ km} = \boxed{} \text{ m}$

5 $760 \text{ g} = \boxed{} \text{ kg}$

6 $0.08 \text{ kg} = \boxed{} \text{ g}$

7 $3500 \text{ kg} = \boxed{}$
tonnes

8 $0.4 \text{ litres} = \boxed{} \text{ ml}$

9 $2250 \text{ ml} = \boxed{}$
litres

10 $6 \text{ m}^2 = \boxed{} \text{ cm}^2$

11 $82\,000 \text{ cm}^2 = \boxed{}$
 m^2

12 $3.5 \text{ cm}^2 = \boxed{}$
 mm^2

13 $0.5 \text{ m}^3 = \boxed{} \text{ cm}^3$

14 $1\,200\,000 \text{ cm}^3 =$
 $\boxed{} \text{ m}^3$

15 $7000 \text{ mm}^3 = \boxed{}$
 cm^3

16 $4.2 \text{ litres} = \boxed{}$
 cm^3

17 $650 \text{ litres} = \boxed{}$
 m^3

18 $2.4 \text{ km}^2 = \boxed{} \text{ m}^2$

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 A jug holds 1.5 litres of juice. Glasses hold 180 ml.

(a) How many glasses can be filled completely? [2]

Answer

(b) How much juice is left over? [1]

Answer ml

- 2 A garden pond is a cuboid 2.4 m long, 1.5 m wide and 60 cm deep.

(a) Work out the volume of the pond in m^3 . [2]

Answer m^3

(b) Write the volume in litres. [1]

Answer litres

(c) A hose fills the pond at 18 litres per minute. How many hours does it take to fill the empty pond? [2]

Answer hours

- 3 Higher. Units of area.

(a) A rectangle is 2.5 m long and 80 cm wide. Work out its area in cm^2 and in m^2 . [3]

Answer cm^2 m^2

(b) Write 45 000 000 m^2 in km^2 . [1]

Answer km^2

- 4 Higher. Units of volume.

(a) A metal block has volume 0.0006 m^3 . Write this volume in cm^3 . [1]

Answer cm^3

(b) Cubes of side 4 cm are packed into a box measuring 0.2 m by 0.12 m by 0.08 m. How many cubes fit in the box? [3]

Answer

5 A box contains 24 tins. Each tin has a mass of 415 g. The empty box has a mass of 0.6 kg.

(a) Work out the total mass of the full box in kg. **[3]**

Answer kg

(b) A shelf can hold a box of at most 12 kg. What is the greatest number of tins that can be put in the box? **[2]**

Answer

6 A fence is 18.6 m long. It is made from panels that are each 1.8 m wide.

(a) How many panels are needed? **[2]**

Answer

(b) Each panel costs \$24.50. Work out the total cost. **[2]**

Answer \$

(c) Write 18.6 m in millimetres. **[1]**

Answer mm

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Bearings and scale drawings

I can... use three-figure bearings, map scales and scale drawings.

Spec ref: 4.1, 4.4 · Foundation & Higher

A **three-figure bearing** is an angle measured **clockwise from North**. On a **scale drawing** every length is reduced by the same factor, so you can measure the drawing and use the scale to find real lengths.

Key points

- "The bearing of B from A": put your protractor at A, with 0° on the North line.
- Bearing back = bearing $+ 180^\circ$ (or $- 180^\circ$ if the bearing is more than 180°).
- Scale $1 : n$ — real length = drawing length $\times n$. Scale "1 cm to 5 km" — multiply the drawing length by 5 km.

Key words

bearing

clockwise

North line

scale

scale drawing

Worked example

The bearing of B from A is 052° . Find the bearing of A from B.

North lines are parallel: the angle at B between North and BA is $180 + 52$.
Bearing of A from B = **232°**

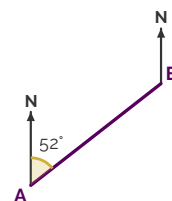


Diagram NOT accurately drawn

Common mistakes

- Measuring the angle from the line to North instead of from North to the line.
- Forgetting to change units after using a map scale (cm $\rightarrow$ m or km).

Exam tip: Bearings questions often need angle facts as well. Mark the parallel North lines on the diagram.

Answer each question. Show your working where it helps.

1

Scale 1 : 25 000. Map distance 7.2 cm. Real distance in km?

2

Scale 1 : 5000. Map distance 3.6 cm. Real distance in m?

3

Scale 1 : 250. A wall is 8 cm on the plan. Real length in m?

4

Scale 1 : 2 000 000. Map distance 4.5 cm. Real distance in km?

5

Scale 1 : 40 000. Real distance 2.4 km. Map distance in cm?

6

Scale 2 cm to 1 km. Real distance 7 km. Map distance?

7

Bearing of North-East

8

Bearing of due West

9

Bearing of Q from P is 062° .

Bearing of P from Q?

10

Bearing of Q from P is 205° . Bearing

of P from Q?

11

Bearing of Q from P is 315° . Bearing of P from Q?

12

Bearing of Q from P is 090° . Bearing of P from Q?

Measure the bearing of Y from X.

13



Diagram accurately drawn

Answer°

Measure the bearing of Y from X.

14



Diagram accurately drawn

Answer°

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

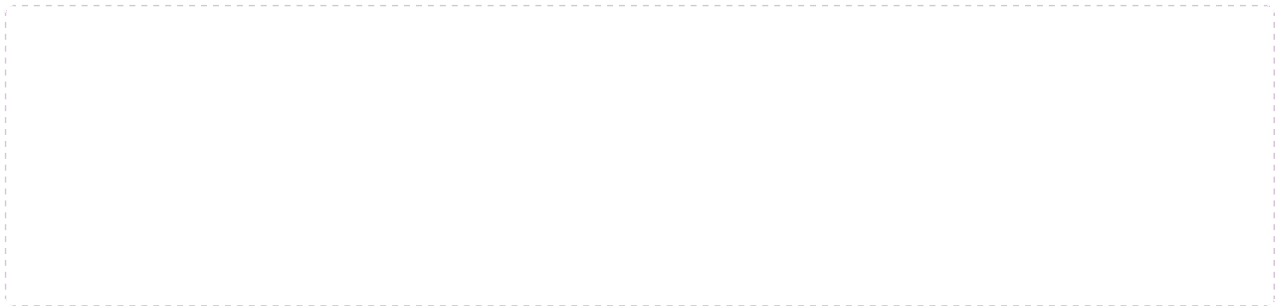
Answer all questions. Show your working. Marks are shown in brackets.

- 1 A rectangular field is 120 m long and 75 m wide. A scale drawing of the field is made using a scale of 1 : 1500.

(a) Work out the length and width of the field on the drawing. [2]

Answer cm by cm

(b) Make the scale drawing. Measure the diagonal and use it to find the real length of the diagonal. [2]



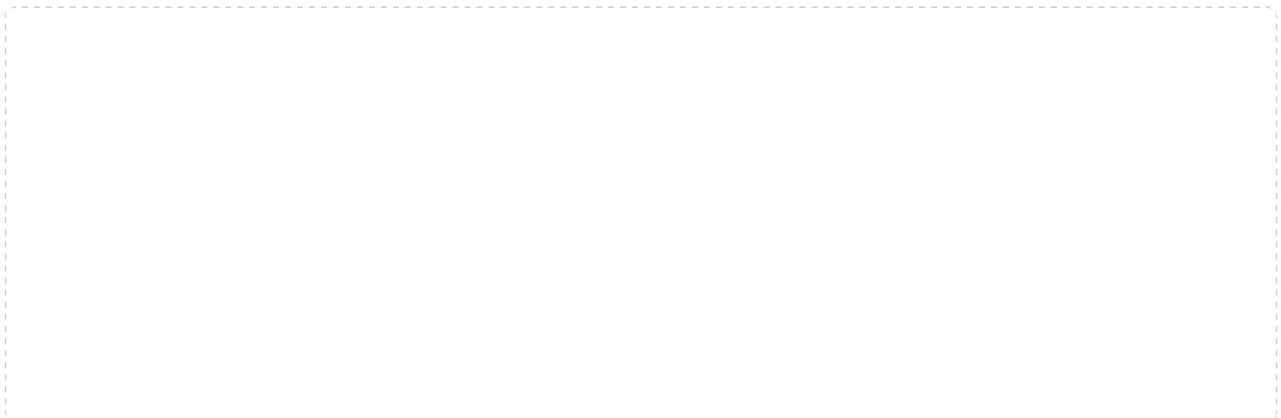
Answer m

(c) Work out the area of the rectangle on the drawing. [1]

Answer cm²

- 2 Town B is 30 km from town A on a bearing of 040°. Town C is 45 km from town B on a bearing of 130°.

(a) Make a scale drawing using a scale of 1 cm to 5 km. [2]



(b) Use your drawing to find the distance AC in km. [2]

Answer km

(c) Use your drawing to find the bearing of C from A. [2]

Answer°

- 3 Q is due East of P. The bearing of R from P is 052° . The bearing of R from Q is 320° . Work out the size of angle PRQ. [4]

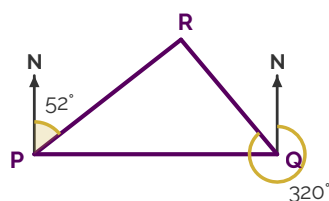


Diagram NOT accurately drawn

Answer°

- 4 A map has a scale of 1 : 50 000. A footpath is 6.8 cm long on the map.

(a) Work out the real length of the footpath in km. [2]

Answer km

(b) Ravi walks along the footpath at 4 km/h. How many minutes does he take? [1]

Answer minutes

- 5 Bearings.

(a) The bearing of a ship from a lighthouse is 245° . Work out the bearing of the lighthouse from the ship. [1]

Answer°

(b) The bearing of A from B is three times the bearing of B from A. Both bearings are less than 360° . Find both bearings. [3]

Answer° and°

- 6 On a plan with a scale of 1 : 200, a room measures 4.2 cm by 3.5 cm. Work out the real area of the floor in m^2 . [3]

Answer m^2

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Constructions

I can... measure and draw accurately and construct bisectors, perpendiculars, angles and triangles.

Spec ref: 4.5 · Foundation & Higher

A **construction** uses only a ruler (straight edge) and compasses, so it is accurate. Do not rub out your arcs. A protractor may be used only when a question allows it.

Key points

- Perpendicular bisector of AB: equal arcs from A and B on both sides; join the crossings.
- Angle bisector: arc from the vertex cuts both arms; equal arcs from those two points cross; join to the vertex.
- A 60° angle comes from an equilateral triangle; bisect it to get 30° . Bisect a 90° angle to get 45° .

Key words

construct

compasses

perpendicular bisector

angle bisector

arc

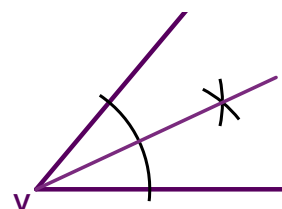
Worked example

Bisect angle V.

Compasses on V: draw an arc cutting both arms.

From each crossing point, draw arcs with the same radius so they meet inside the angle.

Join V to the point where these arcs meet.



Common mistakes

- Changing the compass width between the two arcs.
- Drawing the bisector by eye, without arcs.

Exam tip: Check your constructions with a protractor or ruler afterwards; they should be within 1–2 mm or 1–2°.

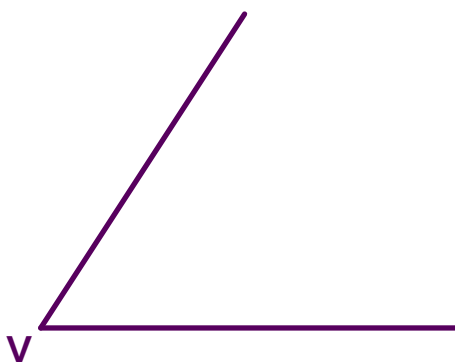
Use a ruler and compasses only, unless a protractor is needed for measuring.

- 1 Measure the length of AB.



Answer cm

- 2 Measure angle V.



Answer°

- 3 Measure the reflex angle.

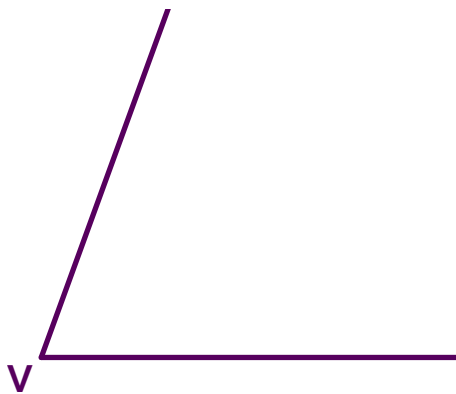


Answer°

- 4 Construct the perpendicular bisector of AB.



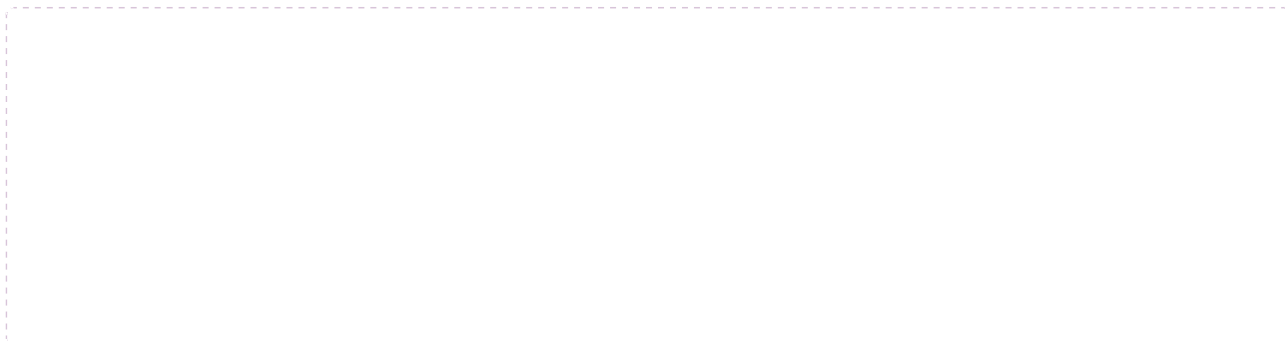
- 5 Construct the bisector of angle V.



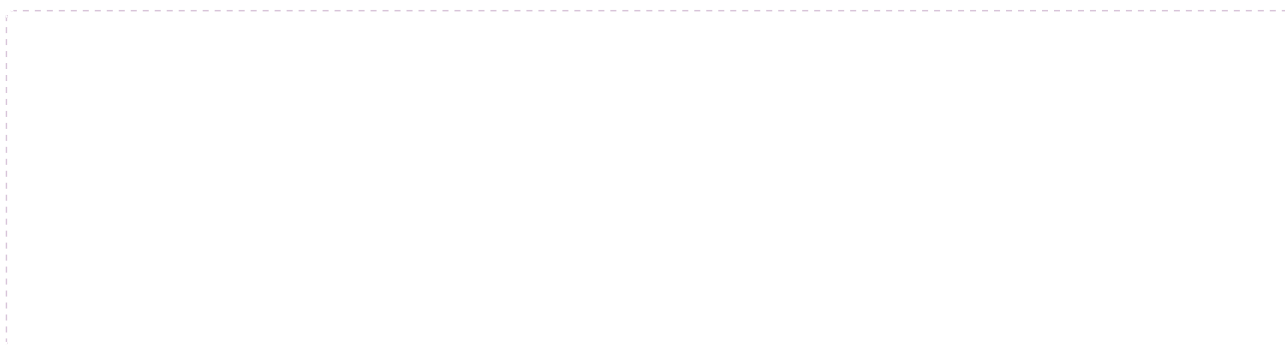
- 6 Construct an angle of 60° at A.



- 7 Construct triangle PQR with $PQ = 7$ cm, $PR = 5$ cm and $QR = 4$ cm.



- 8 Draw triangle ABC with $AB = 6$ cm, angle A = 50° and $AC = 4.5$ cm. Measure BC.



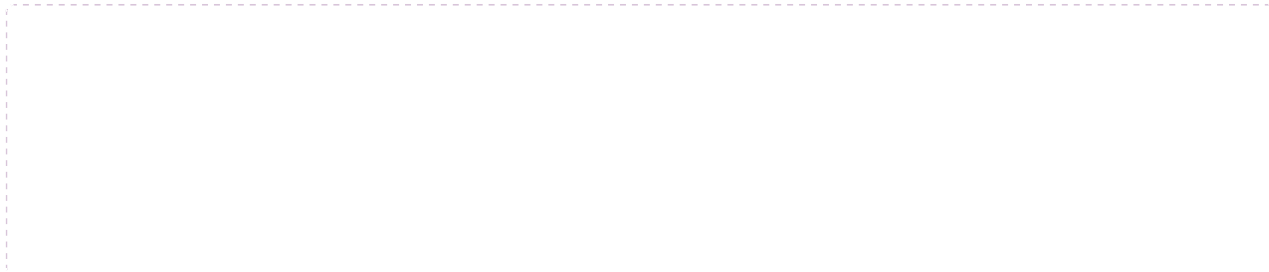
Answer BC = cm

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 Triangle ABC has $AB = 8$ cm, angle $CAB = 40^\circ$ and angle $CBA = 65^\circ$.

(a) Draw triangle ABC accurately. You may use a protractor. [3]



(b) Measure AC and BC. [2]

Answer AC = cm BC = cm

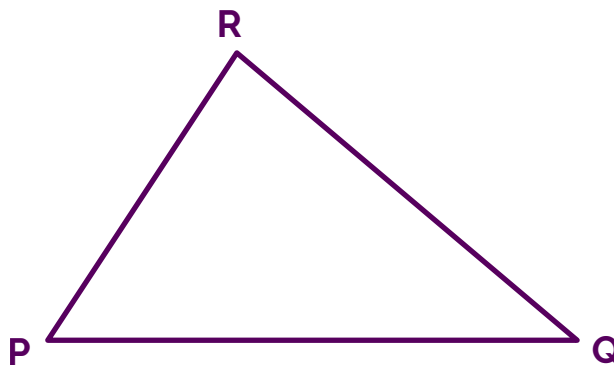
(c) Measure angle ACB. [1]

Answer°

(d) Work out the perimeter of your triangle. [1]

Answer cm

- 2 The triangle PQR is drawn accurately.



(a) Using ruler and compasses only, construct the perpendicular from R to the line PQ. [2]

(b) Measure the perpendicular height of the triangle. [1]

Answer cm

(c) $PQ = 7$ cm. Work out the area of the triangle. [2]

Answer cm^2

(d) Measure PR and angle QPR. [2]

Answer PR = cm angle QPR =°

- 3 Angle ABC is drawn accurately.



(a) Using ruler and compasses only, construct the bisector of angle ABC. [2]

(b) Measure the angle between the bisector and BC. [1]

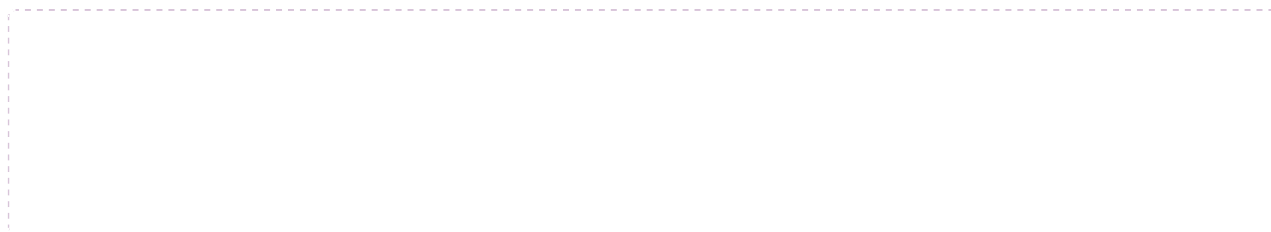
Answer°

(c) Mark the point T on the bisector with $BT = 5$ cm. Measure the perpendicular distance from T to BC. [1]

Answer cm

- 4 A rhombus ABCD has sides of length 5 cm. The diagonal AC is 8 cm long.

(a) Using ruler and compasses only, construct the rhombus. [3]



(b) Measure the diagonal BD. [1]

Answer cm

(c) Measure angle ABC. [1]

Answer°

(d) Use your answer to (b) to work out the area of the rhombus. [1]

Answer cm^2

(e) Write down the perimeter of the rhombus. [1]

Answer cm

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Perimeter and area

I can... find perimeters and areas of triangles, quadrilaterals and compound shapes.

Spec ref: 4.9 · Foundation

Learn the area formulas and always use the **perpendicular height**. To find the area of a compound shape, split it into simple shapes and add, or find a big shape and subtract the part that is missing.

Key points

- Rectangle lw ; triangle $\frac{1}{2}bh$; parallelogram bh ; trapezium $\frac{1}{2}(a + b)h$.
- Perimeter is a length (cm); area is in square units (cm^2).
- To find a missing length, substitute into the formula and solve.

Key words

perimeter

area

perpendicular height

compound shape

trapezium

Worked example

A photo frame is a 10 cm by 8 cm rectangle with a 6 cm by 4 cm hole. Find the shaded area.

Large rectangle: $10 \times 8 = 80 \text{ cm}^2$

Hole: $6 \times 4 = 24 \text{ cm}^2$

Shaded area = $80 - 24 = 56 \text{ cm}^2$

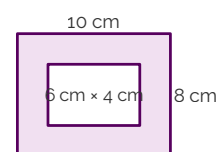


Diagram NOT accurately drawn

Common mistakes

- Adding the lengths of a compound shape you have not worked out first.
- Writing an area in cm instead of cm^2 .

Exam tip: On a compound shape, write every missing length on the diagram before you start.

Work out each area or perimeter.

Area

1



Diagram NOT accurately drawn

Answer A = cm^2

Area

2

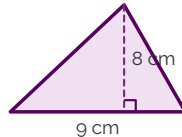


Diagram NOT accurately drawn

Answer A = cm^2

Area

3

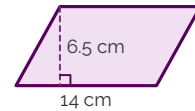


Diagram NOT accurately drawn

Answer A = cm^2

Area

4

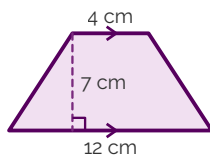


Diagram NOT accurately drawn

Answer A = cm^2

Perimeter of the rhombus

5

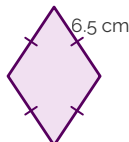


Diagram NOT accurately drawn

Answer P = cm

Perimeter

6

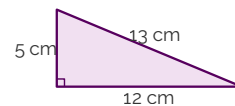


Diagram NOT accurately drawn

Answer P = cm

Area

7

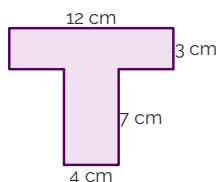


Diagram NOT accurately drawn

Answer A = cm^2

Perimeter

8

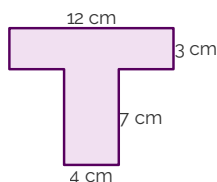


Diagram NOT accurately drawn

Answer P = cm

A rectangle has perimeter 30 cm and length 9 cm. Find its width.

9

Answer cm

A square has perimeter 36 cm. Find its area.

10

Answer cm^2

A triangle has area 45 cm^2 and height 9 cm. Find its base.

11

Answer cm

A parallelogram has area 72 cm^2 and base 9 cm. Find its height.

12

Answer cm

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 A rectangular garden is 15 m long and 9 m wide. It contains a rectangular pond 4 m by 2.5 m. The rest of the garden is lawn.

(a) Work out the area of the lawn. [3]

Answer m²

(b) Grass seed is spread at 40 g per m². Seed is sold in 1 kg boxes costing \$8.75. Work out the cost of the seed. [3]

Answer \$

(c) A fence goes all the way round the garden. How long is the fence? [1]

Answer m

- 2 ABCD is a trapezium. AB is parallel to DC. AB = 7 cm and DC = 13 cm. The area of the trapezium is 60 cm². Work out the perpendicular distance between AB and DC. [3]

Answer cm

- 3 A triangle has vertices at (1, 1), (7, 1) and (4, 6). The units are centimetres.

(a) Work out the area of the triangle. [2]

Answer cm²

(b) A square has the same area as the triangle. Work out the length of a side of the square. Give your answer correct to 3 significant figures. [2]

Answer cm

- 4 A rectangle has length $(2x + 3)$ cm and width $(x - 1)$ cm. Its perimeter is 52 cm.

(a) Work out the value of x . [3]

Answer $x =$

(b) Work out the area of the rectangle. [1]

Answer cm²

- 5 A parallelogram has base 9 cm and perpendicular height 6 cm. A triangle has the same area as the parallelogram. The height of the triangle is 8 cm. Work out the length of its base.

[3]

Answer cm

- 6 A wall is 4.2 m wide and 2.6 m high. It has a door 0.9 m wide and 2 m high. The wall (not the door) is painted with two coats of paint. One litre of paint covers 12 m^2 . Paint is sold in 2.5 litre tins. How many tins are needed?

[4]

Answer

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Circles, arcs and sectors

I can... find circumferences and areas of circles and (Higher) arc lengths, sectors and segments.

Spec ref: 4.9 · Foundation & Higher

Use π from your calculator. The **circumference** is the perimeter of a circle; a **sector** is a "slice" bounded by two radii and an arc. For a sector with angle θ , the fraction of the whole circle is $\theta/360$.

Key points

- $C = \pi d = 2\pi r$; $A = \pi r^2$.
- *Higher:* arc length = $(\theta/360) \times 2\pi r$; sector area = $(\theta/360) \times \pi r^2$.
- *Higher:* area of a segment = area of sector – area of triangle (use $\frac{1}{2}ab \sin C$).

Key words

circumference

radius

diameter

sector

arc

segment

Worked example (Higher)

Find the area and the perimeter of the sector. Give your answers to 3 s.f.

$$\text{Area} = 140/360 \times \pi \times 6^2 = \mathbf{44.0 \text{ cm}^2}$$

$$\text{Arc} = 140/360 \times 2 \times \pi \times 6 = 14.7 \text{ cm}$$

$$\text{Perimeter} = 14.7 + 6 + 6 = \mathbf{26.7 \text{ cm}}$$

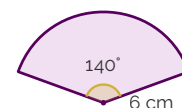


Diagram NOT
accurately drawn

Common mistakes

- Squaring the diameter instead of the radius.
- Leaving out the two straight edges in the perimeter of a sector.

Exam tip: If an answer is asked "in terms of π ", do not use the π button: leave π in the answer, e.g. $25\pi \text{ cm}^2$.

Give your answers correct to 3 significant figures.

Circumference

1

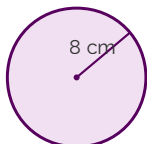


Diagram NOT accurately drawn

Answer $C = \dots\dots \text{ cm}$

Circumference

2

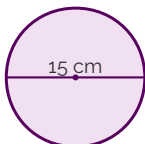


Diagram NOT accurately drawn

Answer $C = \dots\dots \text{ cm}$

Area

3

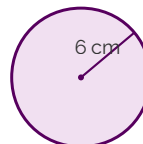


Diagram NOT accurately drawn

Answer $A = \dots\dots \text{ cm}^2$

Area

4

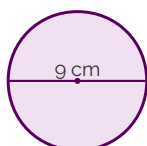


Diagram NOT accurately drawn

Answer $A = \dots\dots \text{ cm}^2$

Area of the semicircle
(radius 5 cm)

5

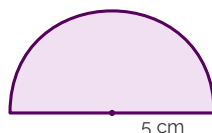


Diagram NOT accurately drawn

Answer $A = \dots\dots \text{ cm}^2$

Perimeter of the
quarter circle

6

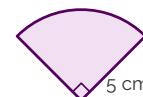


Diagram NOT accurately drawn

Answer $P = \dots\dots \text{ cm}$

Higher: arc length

7



Diagram NOT accurately drawn

Answer $\dots\dots \text{ cm}$

Higher: sector area

8

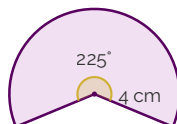


Diagram NOT accurately drawn

Answer $\dots\dots \text{ cm}^2$

Higher: perimeter

9

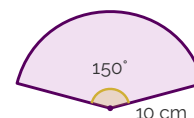


Diagram NOT accurately drawn

Answer $\dots\dots \text{ cm}$

A circle has circumference 100 cm.
Find its radius.

10

Answer $r = \dots\dots \text{ cm}$

A circle has area 50 cm^2 . Find its radius.

11

Answer $r = \dots\dots \text{ cm}$

Higher: a sector of radius 6 cm has area 30 cm^2 .
Find its angle.

12

Answer $\theta = \dots\dots^\circ$

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 A running track is made of two straight sections, each 100 m long, and two semicircular ends. The width across the track is 60 m.

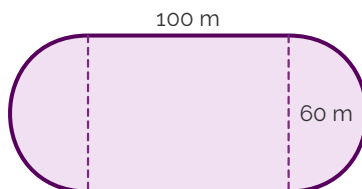


Diagram NOT accurately drawn

- (a) Work out the perimeter of the track. [3]

Answer m

- (b) Work out the area enclosed by the track. [3]

Answer m²

- 2 A pizza has diameter 30 cm. It is cut into 8 equal slices.

- (a) Work out the area of one slice. [2]

Answer cm²

- (b) Work out the length of the curved crust of one slice. [2]

Answer cm

- (c) Work out the perimeter of one slice. [1]

Answer cm

- 3 *Higher.* A sector of a circle has angle 80° and perimeter 30 cm. Work out the radius of the circle. [4]

Answer cm

- 4 A washer is a circle of radius 1.2 cm with a circular hole of radius 0.3 cm in the centre. Work out the area of the washer. [3]

Answer cm²

- 5 Higher. OAB is a sector of a circle, centre O, radius 9 cm. Angle AOB = 120° . Work out the area of the segment between the chord AB and the arc AB.

[4]

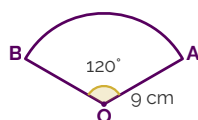


Diagram NOT
accurately drawn

Answer cm^2

- 6 A bicycle wheel has radius 34 cm. It turns 500 times. How far does the bicycle travel? Give your answer in kilometres.

[3]

Answer km

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Prisms and cylinders

I can... find the volume and surface area of cuboids, prisms and cylinders.

Spec ref: 4.10 · Foundation & Higher

The volume of any **prism** is the area of its cross-section multiplied by its length. A cylinder is a circular prism. To find a **surface area**, add the areas of all the faces; sketching the net helps you not to miss any.

Key points

- Volume of prism = area of cross-section $\times$ length; cylinder $V = \pi r^2 h$.
- Curved surface area of a cylinder = $2\pi rh$ (the label of a tin opens out into a rectangle).
- $1 \text{ cm}^3 = 1 \text{ ml}$ and $1000 \text{ cm}^3 = 1 \text{ litre}$.

Key words

prism

cross-section

cylinder

surface area

capacity

Worked example

Find the volume of the prism. Its cross-section is a trapezium.

$$\text{Area of trapezium} = \frac{1}{2} \times (4 + 10) \times 5 = 35 \text{ cm}^2$$

$$\text{Volume} = 35 \times 12 = \mathbf{420 \text{ cm}^3}$$

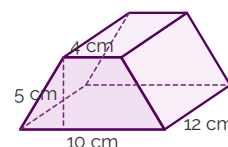


Diagram NOT accurately drawn

Common mistakes

- Multiplying all the lengths of a triangular prism together and forgetting the $\frac{1}{2}$.
- Using the diameter as the radius in $\pi r^2 h$.

Exam tip: Write the area of the cross-section as a separate line of working; it usually earns a method mark.

Give your answers correct to 3 significant figures where necessary.

Volume

1

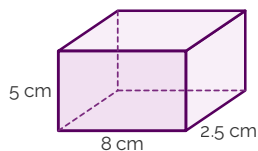


Diagram NOT accurately drawn

Answer cm^3

Total surface area

2

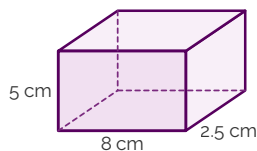


Diagram NOT accurately drawn

Answer cm^2

Volume

3

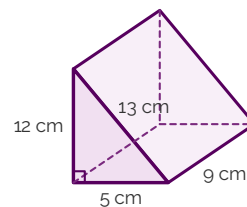


Diagram NOT accurately drawn

Answer cm^3

Total surface area

4

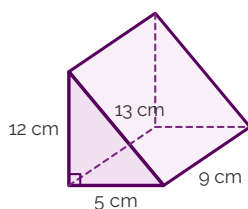


Diagram NOT accurately drawn

Answer cm^2

Volume

5

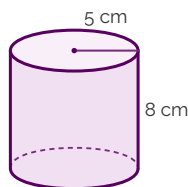


Diagram NOT accurately drawn

Answer cm^3

Curved surface area

6

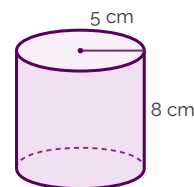


Diagram NOT accurately drawn

Answer cm^2

Total surface area

7

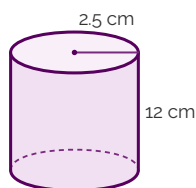


Diagram NOT accurately drawn

Answer cm^2

Volume (10 cm is the diameter)

8

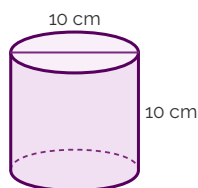


Diagram NOT accurately drawn

Answer cm^3

9

A cube has edges of 4.5 cm. Find its volume.

Answer cm^3

10

A cuboid has volume 360 cm^3 and base 9 cm by 8 cm. Find its height.

Answer cm

11

Higher: a cylinder has volume 1000 cm^3 and height 12 cm. Find its radius.

Answer cm

12

A prism has cross-section area 18.5 cm^2 and length 8 cm. Find its volume.

Answer cm^3

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 A chocolate box is a triangular prism. The cross-section is an isosceles triangle with base 6 cm, height 4 cm and sloping sides 5 cm. The box is 20 cm long.

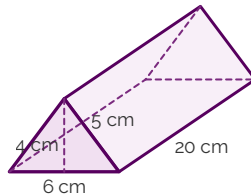


Diagram NOT accurately drawn

- (a) Work out the volume of the box. [2]

Answer cm^3

- (b) Work out the total surface area of the box. [3]

Answer cm^2

- 2 A water trough is in the shape of half a cylinder. The radius is 30 cm and the length is 2 m.

- (a) Work out how many litres of water the trough holds when full. Give your answer correct to 3 significant figures. [4]

Answer litres

- (b) Work out the area of the open rectangular top of the trough. [1]

Answer cm^2

- 3 A cylindrical water tank has radius 0.8 m and height 1.5 m.

- (a) Work out the volume of the tank in m^3 . [2]

Answer m^3

- (b) The full tank is emptied at 20 litres per minute. How long does it take? Give your answer in hours and minutes, to the nearest minute. [3]

Answer h min

- 4 *Higher.* A cylinder has a volume of 750 cm^3 . Its height is twice its radius. Work out the radius.

[3]

Answer cm

- 5 A cuboid tank 30 cm by 20 cm by 10 cm is full of water. All the water is poured into an empty cylinder of radius 8 cm. Work out the depth of the water in the cylinder.

[3]

Answer cm

- 6 A cube has edges of 10 cm. A cylinder of radius 6 cm has the same volume as the cube.

(a) Work out the height of the cylinder.

[3]

Answer cm

(b) Which solid has the larger total surface area? Show your working.

[2]

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Pyramids, cones and spheres

I can... find volumes and surface areas of pyramids, cones, spheres, frustums and composite solids.

Spec ref: 4.10 · Higher

This unit is for the Higher tier. The formulae for the volume and surface area of a cone and a sphere are given on the formula sheet. Composite solids are made of simpler solids: find each part, then add or subtract.

Key points

- Pyramid and cone: volume = $\frac{1}{3} \times \text{base area} \times \text{vertical height}$; cone curved surface area = $\pi r l$.
- Sphere: $V = \frac{4}{3}\pi r^3$, $A = 4\pi r^2$. Hemisphere: half of each, plus πr^2 for the flat face.
- Slant height l , radius r and vertical height h of a cone: $l^2 = r^2 + h^2$.

Key words

pyramid

cone

sphere

slant height

frustum

composite

Worked example

A sphere has radius 6 cm. Find its volume and its surface area.

$$V = \frac{4}{3} \times \pi \times 6^3 = 288\pi = \mathbf{905 \text{ cm}^3}$$

$$A = 4 \times \pi \times 6^2 = 144\pi = \mathbf{452 \text{ cm}^2}$$

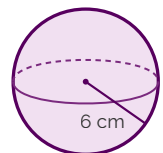


Diagram NOT accurately drawn

Common mistakes

- Using the slant height in the volume of a cone.
- Cubing the diameter instead of the radius.

Exam tip: When a solid is melted and recast, the **volume** stays the same: write "volume before = volume after".

Higher. Give your answers correct to 3 significant figures.

Volume

1

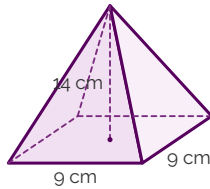


Diagram NOT accurately drawn

Answer cm^3

Volume

2

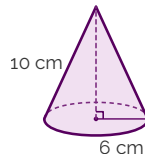


Diagram NOT accurately drawn

Answer cm^3

Curved surface area

3

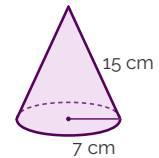


Diagram NOT accurately drawn

Answer cm^2

Volume

4

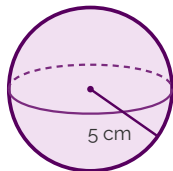


Diagram NOT accurately drawn

Answer cm^3

Surface area (10 cm is the diameter)

5

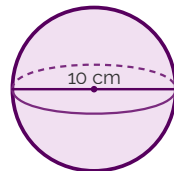


Diagram NOT accurately drawn

Answer cm^2

Volume

6



Diagram NOT accurately drawn

Answer cm^3

Total surface area

7



Diagram NOT accurately drawn

Answer cm^2

Total surface area

8

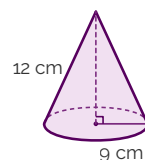


Diagram NOT accurately drawn

Answer cm^2

A pyramid has a triangular base of area 24 cm^2 and height 7 cm. Find its volume.

9

Answer cm^3

A sphere has volume 500 cm^3 . Find its radius.

10

Answer cm

A cone has volume 100 cm^3 and radius 4 cm. Find its height.

11

Answer cm

A hemisphere has volume 2000 cm^3 . Find its radius.

12

Answer cm

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 A model rocket is a cylinder of radius 3 cm and height 12 cm with a cone of radius 3 cm and height 4 cm on top. Work out the volume of the rocket. Give your answer correct to 3 significant figures. [4]

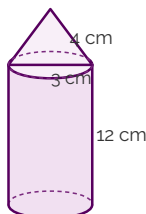


Diagram NOT
accurately drawn

Answer cm³

- 2 A solid sphere of radius 3 cm is melted down and recast as a solid cone with base radius 3 cm. [3]

(a) Work out the height of the cone.

Answer cm

(b) Work out the curved surface area of the cone.

Answer cm²

- 3 A bowl is a hemisphere with inside radius 12 cm. [3]

(a) Work out the capacity of the bowl in litres.

Answer litres

(b) How many full 250 ml cups of water can be poured from the full bowl?

Answer

- 4 A pyramid has a square base of side 6 cm. Each triangular face has a perpendicular height (slant height) of 5 cm.

(a) Work out the total surface area of the pyramid. [2]

Answer cm^2

(b) Show that the vertical height of the pyramid is 4 cm. [2]

(c) Work out the volume of the pyramid. [1]

Answer cm^3

- 5 A lampshade is a frustum. It is made by removing a cone of radius 4 cm and height 12 cm from the top of a cone of radius 10 cm and height 30 cm. Work out the volume of the frustum. [4]

Answer cm^3

- 6 Three tennis balls of radius 3.5 cm fit exactly inside a cylindrical tube of radius 3.5 cm and height 21 cm. Work out the volume of empty space in the tube. [4]

Answer cm^3

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Similar shapes

I can... use scale factors in similar shapes, including (Higher) areas and volumes of similar figures.

Spec ref: 4.11 · Foundation & Higher

Two shapes are **similar** when one is an enlargement of the other. Corresponding angles are equal and corresponding sides are in the same ratio. Parallel lines often create similar triangles. *Higher:* areas scale by k^2 and volumes by k^3 .

Key points

- Scale factor k = length on the image $\div$ corresponding length on the object.
- Lengths $\times k$; *Higher:* areas $\times k^2$; volumes (and masses of the same material) $\times k^3$.
- Ratio of lengths $a : b$ gives areas $a^2 : b^2$ and volumes $a^3 : b^3$.

Key words

similar

scale factor

corresponding

ratio

enlargement

Worked example

AB is parallel to DE. Find the length CE.

Triangles ABC and EDC are similar (alternate angles, vertically opposite angles).

$$k = 6 \div 9 = \frac{2}{3}$$

$$CE = 7.5 \times \frac{2}{3} = \mathbf{5 \text{ cm}}$$

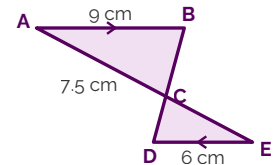


Diagram NOT accurately drawn

Common mistakes

- Matching the wrong sides: match the sides opposite equal angles.
- *Higher:* using k instead of k^3 for a mass or a volume.

Exam tip: Write the scale factor as a fraction if it is not a simple decimal, e.g. $\frac{2}{3}$, to avoid rounding errors.

Find the missing values. Questions 7–12 are Higher.

The rectangles are similar. Find x .

1

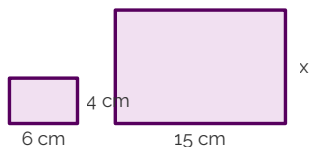


Diagram NOT accurately drawn

Answer $x = \dots\dots$

DE is parallel to BC. Find x .

2

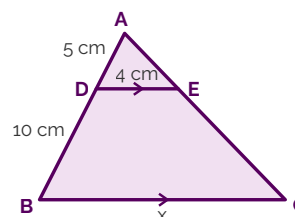


Diagram NOT accurately drawn

Answer $x = \dots\dots$

3

Scale factor from 3.6 cm to 9 cm

4

Triangles with sides 4, 6, 7 cm and 10, 15, x cm are similar. Find x .

5

A 12 cm by 8 cm photo is enlarged to 18 cm long. New width?

6

A model is made to a scale of 1 : 20. A real door is 1.6 m tall. Model door height in cm?

7

Higher: lengths in ratio 2 : 5. Ratio of areas?

8

Higher: area scale factor 16. Length scale factor?

9

Higher: small area 12 cm², $k = 3$. Large area?

10

Higher: volumes in ratio 8 : 125. Ratio of lengths?

11

Higher: small volume 54 cm³, lengths in ratio 2 : 3. Large volume?

12

Higher: large surface area 500 cm², $k = 2.5$ (small to large). Small surface area?

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 AB is parallel to DE. The lines AE and BD meet at C. AB = 9 cm, DE = 6 cm and AC = 7.5 cm.

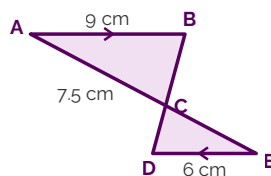


Diagram NOT accurately drawn

- (a) Explain why triangles ABC and EDC are similar. [1]

- (b) Work out the length of CE. [2]

Answer cm

- (c) BD = 12 cm. Work out the length of BC. [2]

Answer cm

- 2 Rectangle P is 8 cm by 5 cm. Rectangle Q is 12 cm by 7.5 cm.

- (a) Show that the rectangles are similar. [2]

- (b) Write down the ratio of the perimeters of P and Q in its simplest form. [1]

Answer :

- (c) *Higher.* Write down the ratio of the areas of P and Q. [1]

Answer :

- 3 *Higher.* Two solid cones are mathematically similar. Their heights are 10 cm and 15 cm.

- (a) The surface area of the small cone is 120 cm^2 . Work out the surface area of the large cone. [2]

Answer cm^2

- (b) The volume of the large cone is 405 cm^3 . Work out the volume of the small cone. [2]

Answer cm^3

4 *Higher.* Two containers are mathematically similar. Their capacities are 250 ml and 2 litres.

(a) The small container is 9 cm tall. Work out the height of the large container. **[3]**

Answer cm

(b) The label on the large container has area 180 cm^2 . Work out the area of the label on the small container. **[2]**

Answer cm^2

5 *Higher.* Two statues made of the same metal are mathematically similar. Their heights are 30 cm and 75 cm. The small statue has a mass of 2.4 kg. Work out the mass of the large statue. **[3]**

Answer kg

6 In triangle ABC, D is on AB and E is on AC, and DE is parallel to BC. $AD = x\text{ cm}$, $DB = 4\text{ cm}$, $DE = 6\text{ cm}$ and $BC = 10\text{ cm}$.

(a) Work out the value of x . **[3]**

Answer $x = \dots\dots\dots$

(b) $EC = 5\text{ cm}$. Work out the length of AE. **[1]**

Answer cm

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Circle properties

I can... use the properties of tangents and chords to find angles and lengths in circles.

Spec ref: 4.6 · Foundation & Higher

Learn the circle words: radius, diameter, chord, tangent, arc, sector and segment. Three facts about chords and tangents let you find angles and lengths; Pythagoras' theorem is often needed as well.

Key points

- A tangent is perpendicular to the radius at the point where it touches the circle.
- Two tangents from a point outside a circle are equal in length.
- The perpendicular from the centre to a chord bisects the chord.

Key words

tangent

chord

radius

sector

segment

Worked example

PT is a tangent to the circle, centre O. OP = 13 cm and OT = 5 cm. Find PT.

Angle OTP = 90° (tangent $\perp$ radius).

$$PT = \sqrt{(13^2 - 5^2)} = \sqrt{144} = \mathbf{12 \text{ cm}}$$

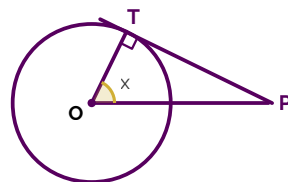


Diagram NOT accurately drawn

Common mistakes

- Forgetting that OA = OB (radii), so triangle OAB is isosceles.
- Using the whole chord instead of half of it in Pythagoras.

Exam tip: Draw in any radii you need. A radius to a tangent point or to the end of a chord usually unlocks the question.

O is the centre of each circle. Find the unknown and give a reason.

1

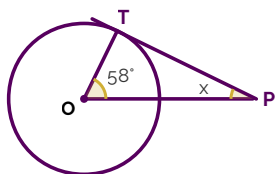


Diagram NOT accurately drawn

Answer $x = \dots\dots$

2

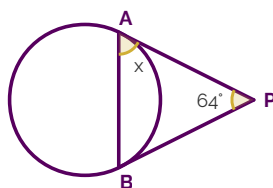


Diagram NOT accurately drawn

Answer $x = \dots\dots$

3

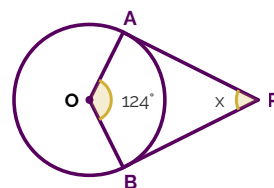


Diagram NOT accurately drawn

Answer $x = \dots\dots$

OM $\perp$ AB and AB = 10 cm.

4

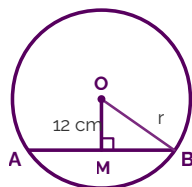


Diagram NOT accurately drawn

Answer $r = \dots\dots$

OM $\perp$ AB. Find AB.

5

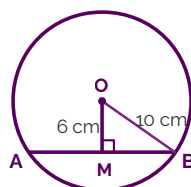


Diagram NOT accurately drawn

Answer AB = $\dots\dots$

PT is a tangent and OT = 5 cm.

6

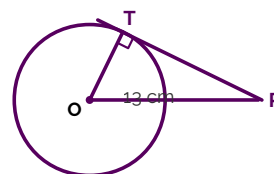


Diagram NOT accurately drawn

Answer PT = $\dots\dots$

ST is a tangent at A.

7

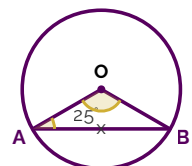


Diagram NOT accurately drawn

Answer $x = \dots\dots$

8

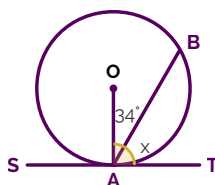


Diagram NOT accurately drawn

Answer $x = \dots\dots$

PA and PB are tangents.

9

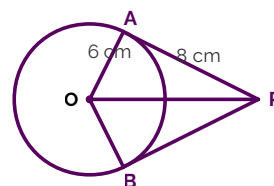


Diagram NOT accurately drawn

Answer OP = $\dots\dots$

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 PT is a tangent to a circle, centre O, at T. The radius is 7 cm and $PT = 24$ cm.

(a) Work out the length OP.

[2]

Answer cm

(b) Work out the shortest distance from P to the circle.

[1]

Answer cm

(c) Work out the area of triangle OTP.

[2]

Answer cm^2

- 2 PA and PB are tangents to a circle, centre O, from a point P. Angle $AOB = 110^\circ$.

(a) Write down the size of angle OAP. Give a reason.

[1]

Answer $^\circ$

(b) Work out the size of angle APB.

[2]

Answer $^\circ$

(c) Work out the size of angle PAB. Give a reason.

[2]

Answer $^\circ$

- 3 A chord AB of a circle has length 18 cm. The distance from the centre O to AB is 5 cm.

(a) Work out the radius of the circle. Give your answer correct to 3 significant figures.

[3]

Answer cm

(b) Another chord is 8 cm from O. Work out its length.

[2]

Answer cm

- 4 Circle words.

Description	Name
A straight line joining two points on the circle	
A straight line that touches the circle at one point	
Region between two radii and an arc	
Region between a chord and an arc	

(a) Complete the table.

[4]

- 5 A and B are points on a circle, centre O. Angle $OAB = 2x^\circ$ and angle $AOB = (5x + 9)^\circ$. Work out the size of angle AOB. [3]

Answer°

- 6 PT is a tangent to a circle, centre O, at T. Angle $OPT = 3y^\circ$ and angle $TOP = (5y + 2)^\circ$. Work out the size of angle TOP. [3]

Answer°

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Circle theorems

I can... use the circle theorems and the intersecting chord properties, giving reasons.

Spec ref: 4.6, 4.7 · Higher

These theorems are for the Higher tier. Learn each one with its exact wording, because you must quote it as a reason. Look for radii, diameters, cyclic quadrilaterals and tangents in every diagram.

Key points

- Angle at the centre = $2 \times$ angle at the circumference.
Angle in a semicircle = 90° . Angles in the same segment are equal.
- Opposite angles of a cyclic quadrilateral sum to 180° .
Alternate segment theorem: tangent–chord angle = angle in the alternate segment.
- Intersecting chords: $AX \times XB = CX \times XD$. From an external point P: $PA \times PB = PC \times PD = PT^2$.

Key words

circumference

cyclic quadrilateral

alternate segment

intersecting chords

subtended

Worked example

Chords AB and CD meet at X. $AX = 4$ cm, $XB = 9$ cm and $CX = 6$ cm. Find XD.

$$AX \times XB = CX \times XD$$

$$4 \times 9 = 6 \times XD, \text{ so } XD = \mathbf{6 \text{ cm}}$$

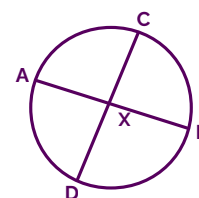


Diagram NOT
accurately drawn

Common mistakes

- Using the angle-at-the-centre theorem when the two angles stand on different arcs.
- For the external case, using $PA \times AB$ instead of $PA \times PB$.

Exam tip: If you cannot see the next step, add a radius or a chord: many theorems need an extra line.

Higher. O is the centre where shown. Find x and give a reason.

1

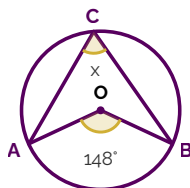


Diagram NOT accurately drawn

Answer $x = \dots\dots$

2

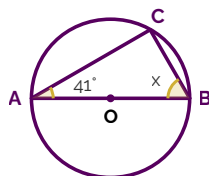


Diagram NOT accurately drawn

Answer $x = \dots\dots$

3

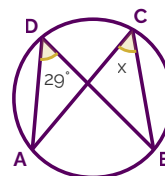


Diagram NOT accurately drawn

Answer $x = \dots\dots$

4

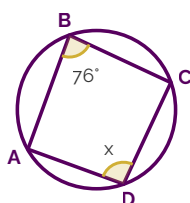


Diagram NOT accurately drawn

Answer $x = \dots\dots$

5

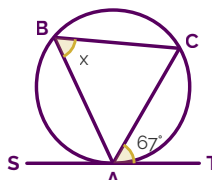


Diagram NOT accurately drawn

Answer $x = \dots\dots$

6

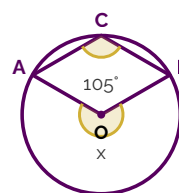


Diagram NOT accurately drawn

Answer $x = \dots\dots$

Lengths in cm.

7

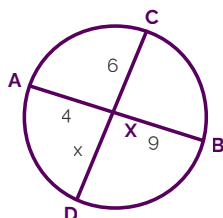


Diagram NOT accurately drawn

Answer $x = \dots\dots$

Lengths in cm.

8

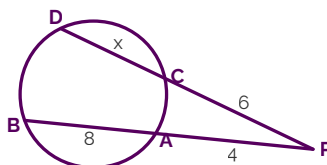


Diagram NOT accurately drawn

Answer $x = \dots\dots$

PT is a tangent. Lengths in cm.

9

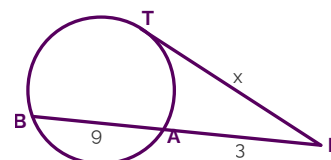


Diagram NOT accurately drawn

Answer $x = \dots\dots$

10

A cyclic quadrilateral has opposite angles $3x$ and $2x$. Find x .

Answer $x = \dots\dots$

11

An exterior angle of a cyclic quadrilateral is 98° . Find the interior opposite angle.

Answer $\dots\dots^\circ$

12

Chords AB and CD cross at X. $AX = 3$ cm, $XB = 8$ cm, $XD = 4$ cm. Find CX.

Answer $\dots\dots$ cm

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 A, B, C and D lie on a circle, centre O. Angle $BAD = 64^\circ$.

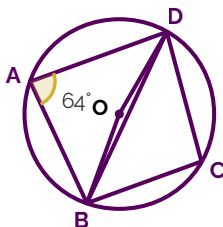


Diagram NOT accurately drawn

- (a) Work out angle BCD. Give a reason.

[2]

Answer

- (b) Work out angle BOD. Give a reason.

[2]

Answer

- (c) Work out angle OBD.

[2]

Answer

- 2 ST is a tangent to the circle at A. Angle $SAB = 48^\circ$ and angle $BAC = 70^\circ$.

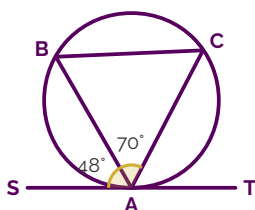


Diagram NOT accurately drawn

- (a) Find angle ACB. Give a reason.

[2]

Answer

- (b) Find angle ABC.

[1]

Answer

- (c) Is BC a diameter of the circle? Explain your answer.

[1]

- 3 Chords AB and CD of a circle intersect at X inside the circle. $AX = 5$ cm, $XB = 8$ cm and $CD = 14$ cm. Work out the lengths CX and XD.

[4]

Answer cm and cm

- 4 P is a point outside a circle. A line from P meets the circle at A and B, with $PA = 5$ cm and $AB = 7$ cm. Another line from P meets the circle at C and D, with $PC = 6$ cm.

(a) Work out the length CD.

[3]

Answer cm

(b) A tangent from P touches the circle at T. Work out PT.

[2]

Answer cm

- 5 Prove that the angle subtended by an arc at the centre of a circle is twice the angle subtended at the circumference. Draw a diagram to help you.

[4]

- 6 AB is a diameter of a circle. C and D lie on the circle on opposite sides of AB. Angle $CAB = 35^\circ$. Work out angle ADC. Give reasons.

[3]

Answer°

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Congruence and geometrical proof

I can... prove that triangles are congruent and write geometrical proofs with reasons.

Spec ref: 4.7 · Higher

Two triangles are **congruent** if they are exactly the same shape and size. You only need to show three facts, using one of the four conditions. A **proof** is a chain of statements, each with a reason, that ends with what you were asked to show.

Key points

- SSS: three pairs of equal sides. SAS: two sides and the angle between them.
- ASA (or AAS): two angles and a corresponding side. RHS: right angle, hypotenuse and one other side.
- AAA is **not** a test for congruence: it only shows the triangles are similar.

Key words

congruent

SSS

SAS

ASA

RHS

proof

Worked example

ABCD is a parallelogram. Prove that triangles ABC and CDA are congruent.

AB = CD and BC = DA (opposite sides of a parallelogram are equal).

AC is common to both triangles.

So the triangles are congruent (**SSS**).

Common mistakes

- Quoting SSA (two sides and an angle that is not between them): it is not a valid test.
- Leaving out the reason for a statement, or stating the conclusion without the condition.

Exam tip: End a congruence proof with a sentence naming the condition, e.g. "so ABM and ACM are congruent (SAS)".

For each pair, decide whether the triangles must be congruent. If they are, give the condition (SSS, SAS, ASA/AAS or RHS).

1

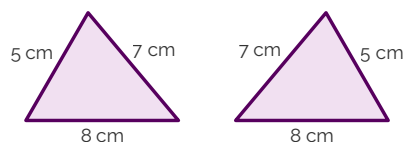


Diagram NOT accurately drawn

Answer

2

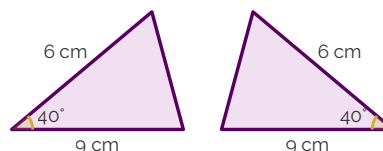


Diagram NOT accurately drawn

Answer

Both triangles have a right angle.

3



Diagram NOT accurately drawn

Answer

4



Diagram NOT accurately drawn

Answer

5

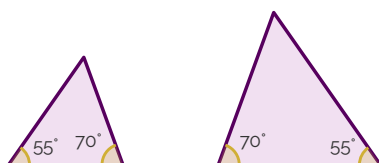


Diagram NOT accurately drawn

Answer

6

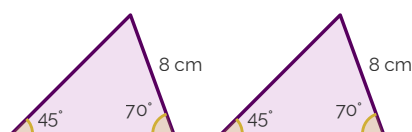


Diagram NOT accurately drawn

Answer

7

Triangle P has sides 5, 6 and 7 cm.
Triangle Q has sides 5, 6 and 8 cm. Are they congruent?

Answer

8

Which of SSS, SAS, AAA, RHS is **not** a valid condition for congruence?

Answer

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure

Answer all questions. Show your working. Marks are shown in brackets.

- 1 ABCD is a parallelogram with diagonal AC.

(a) Prove that triangle ABC is congruent to triangle CDA.

[3]

(b) Hence explain why angle ABC = angle CDA.

[1]

- 2 ABC is an isosceles triangle with $AB = AC$. M is the midpoint of BC. Prove that triangles ABM and ACM are congruent, and hence show that AM is perpendicular to BC.

[4]

- 3 ABCD is a square. E is a point on BC and F is a point on CD so that $BE = CF$. Prove that $AE = BF$.

[4]

- 4 The straight lines AB and CD bisect each other at X. Prove that $AC = BD$ and that AC is parallel to DB. [4]

- 5 Geometrical proof.

(a) Triangle ABC has a line through A parallel to BC. Use this line to prove that the angles of a triangle add up to 180° . [3]

(b) Use part (a) to prove that the angles of any quadrilateral add up to 360° . [2]

- 6 ABCD is a kite with $AB = AD$ and $CB = CD$.

(a) Prove that the diagonal AC bisects angle BAD. [3]

(b) Explain why angle ABC = angle ADC. [1]

Reflect: ☐ Red — not yet ☐ Amber — nearly ☐ Green — secure



CHECK

End-of-book check

End-of-book check

Name _____ Date _____ Score _____ / 12

Answer every question. Compare your score with the starting point check.

Find x .

1

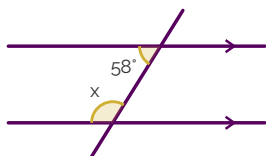


Diagram NOT accurately drawn

Answer $x = \dots\dots$

2

Work out the interior angle of a regular decagon.

Answer $\dots\dots^\circ$

3

The bearing of B from A is 300° . Find the bearing of A from B.

Answer $\dots\dots^\circ$

4

Find the area of a circle with radius 7 cm (3 s.f.).

Answer $\dots\dots \text{cm}^2$

5

Higher: find the area of a sector with angle 60° and radius 9 cm (3 s.f.).

Answer $\dots\dots \text{cm}^2$

6

Find the total surface area of a cuboid 4 cm by 3 cm by 2 cm.

Answer $\dots\dots \text{cm}^2$

7

Higher: find the volume of a cone with radius 6 cm and height 7 cm (3 s.f.).

Answer $\dots\dots \text{cm}^3$

8

Higher: find the surface area of a sphere with radius 2.5 cm (3 s.f.).

Answer $\dots\dots \text{cm}^2$

9

Two similar shapes have lengths in the ratio 3 : 5. A length on the small shape is 12 cm. Find the matching length on the large shape.

Answer $\dots\dots \text{cm}$

10

Higher: two similar shapes have lengths in the ratio 1 : 3. Write down the ratio of their areas.

Answer $\dots\dots : \dots\dots$

11

Two tangents from P touch a circle at A and B. Angle APB = 40° . Find angle PAB.

Answer $\dots\dots^\circ$

12

Higher: chords AB and CD cross at X. AX = 2 cm, XB = 12 cm and CX = 3 cm. Find XD.

Answer $\dots\dots \text{cm}$



Practice paper

Name _____ Date _____ Marks _____ / 60

Time: 1 hour 15 minutes

Calculator allowed. Use the π button on your calculator.Give answers to 3 significant figures unless told otherwise. Questions marked *Higher* are for Higher tier students.

Total: 60 marks

Answer all questions. Show your working. Diagrams are NOT accurately drawn unless otherwise stated.

- 1 The diagram shows two parallel lines crossed by a straight line.

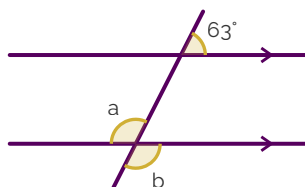


Diagram NOT accurately drawn

- (a) Find the size of angle a. Give a reason.

[2]

Answer a =°

- (b) Find the size of angle b. Give a reason.

[2]

Answer b =°

- 2 Each interior angle of a regular polygon is 156° .

- (a) Work out the number of sides of the polygon.

[3]

Answer

- (b) Work out the sum of its interior angles.

[1]

Answer°

3 Bearings and scale.

(a) The bearing of B from A is 213° . Find the bearing of A from B. [1]

Answer $^\circ$

(b) On a map with scale 1 : 20 000, a road is 9.6 cm long. Work out the real length in km. [2]

Answer km

(c) Q is due East of P. The bearing of R from P is 040° and the bearing of R from Q is 320° . Show that triangle PQR is isosceles. [2]

4 The line AB is drawn accurately.



(a) Using ruler and compasses only, construct the perpendicular bisector of AB. [2]

(b) The bisector meets AB at M. Measure AM. [1]

Answer cm

5 The shape is made from a rectangle and an isosceles triangle.

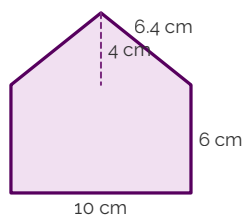


Diagram NOT accurately drawn

(a) Work out the area of the shape. [3]

Answer cm^2

(b) Work out the perimeter of the shape. [2]

Answer cm

- 6 A semicircle has radius 7 cm.

(a) Work out its area.

[2]

Answer cm^2

(b) Work out its perimeter.

[2]

Answer cm

- 7 Higher. OAB is a sector of a circle, centre O, radius 10 cm. Angle AOB = 72° .

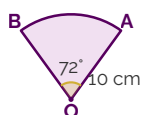


Diagram NOT
accurately drawn

(a) Work out the arc length AB.

[2]

Answer cm

(b) Work out the area of the sector.

[2]

Answer cm^2

- 8 A prism has a right-angled triangle as its cross-section. The sides of the triangle are 6 cm, 8 cm and 10 cm. The prism is 15 cm long.

(a) Work out the volume of the prism.

[2]

Answer cm^3

(b) Work out the total surface area of the prism.

[3]

Answer cm^2

- 9 Higher. A solid is made from a cylinder of radius 4 cm and height 10 cm with a hemisphere of radius 4 cm on top. Work out the volume of the solid. Give your answer correct to 3 significant figures.

[4]

Answer cm^3

- 10** In triangle ABC, D is on AB and E is on AC. DE is parallel to BC. AD = 4 cm, DB = 6 cm and DE = 5 cm.

(a) Work out the length of BC.

[3]

Answer cm

(b) *Higher.* The area of triangle ADE is 8 cm^2 . Work out the area of triangle ABC.

[2]

Answer cm^2

- 11** PA and PB are tangents to a circle, centre O. Angle APB = 52° .

(a) Write down the size of angle OAP. Give a reason.

[1]

Answer $^\circ$

(b) Work out the size of angle AOB.

[2]

Answer $^\circ$

- 12** *Higher.* A, B, C and D lie on a circle, centre O. Angle ADC = 118° .

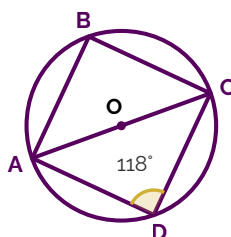


Diagram NOT accurately drawn

(a) Work out angle ABC. Give a reason.

[2]

Answer $^\circ$

(b) Work out the obtuse angle AOC. Give a reason.

[2]

Answer $^\circ$

- 13** *Higher.* P is outside a circle. A line from P meets the circle at A and B, with PA = 4 cm and AB = 5 cm. Another line from P meets the circle at C and D, with PC = 3 cm. Work out CD.

[3]

Answer cm

- 14** *Higher.* AB is parallel to CD and $AB = CD$. The lines AD and BC meet at M. Prove that M is the midpoint of AD. **[4]**

- 15** Units.

(a) Change 2.5 m^3 to litres. **[1]**

Answer litres

(b) *Higher.* Change $45\,000 \text{ cm}^2$ to m^2 . **[1]**

Answer m^2

(c) Change 0.75 km to millimetres. **[1]**

Answer mm



Mark schemes list the points that earn marks. Accept equivalent answers and follow-through where working is correct. M = method mark, A = accuracy mark, B = independent mark.

Starting point check

- 1 106° (angles on a straight line)
- 2 $65^\circ ((180 - 50) \div 2)$
- 3 720°
- 4 2
- 5 3200 m
- 6 180°
- 7 28 cm^2
- 8 20 cm^2
- 9 31.4 cm
- 10 141 cm^3
- 11 2.5
- 12 tangent

Unit 1 · Sheet A — Angles, lines and triangles

- 1 52° (angles on a straight line sum to 180°)
- 2 135° (angles at a point sum to 360°)
- 3 139° (angles on a straight line: $180 - 41$)
- 4 42° (angles in a triangle sum to 180°)
- 5 52° (base angles of an isosceles triangle are equal: $180 - 2 \times 64$)
- 6 60° (equilateral triangle)
- 7 118° (alternate angles are equal)
- 8 125° (corresponding angles are equal)
- 9 114° (co-interior angles sum to 180°)
- 10 $x = 40$ ($3x + x + 20 = 180$)
- 11 129° (exterior angle = $58 + 71$)
- 12 $x = 46$ ($2x + 2x + x + 40 + 90 = 360$)

Unit 1 · Sheet B — Angles, lines and triangles

- 1 (a) $x = 132^\circ$ B1; corresponding angles are equal B1 [2] (b) $y = 48^\circ$ B1; angles on a straight line sum to 180° B1 [2] (c) 48° B1 [1]
- 2 (a) $(180 - 38) \div 2$ M1; 71° A1 [2] (b) $y = 71^\circ$ B1 ft; alternate angles are equal B1 [2] (c) 71° B1 ft [1]
- 3 (a) $x + 10 + 2x + 3x - 40 = 180$ M1; $6x = 210$ M1; $x = 35$ A1 [3] (b) 70° B1 ft (angles 45° , 70° , 65°) [1] (c) acute-angled (all angles less than 90°) / scalene (all angles different) B1 [1]
- 4 (a) $4y - 15 = 2y + 35$ (vertically opposite angles are equal) M1; $y = 25$ A1 [2] (b) $4 \times 25 - 15 = 85^\circ$ M1; $180 - 85 = 95^\circ$ A1 [2]
- 5 (a) $67 + 112 = 179$ M1; not parallel, because co-interior angles of parallel lines sum to 180° A1 [2] (b) 68° B1 [1]
- 6 angle ACB = $180 - \text{angle ACD}$ (angles on a straight line sum to 180°) B1; angle ACB = $180 - \text{angle BAC} - \text{angle ABC}$ (angles in a triangle sum to 180°) B1; so angle ACD = angle BAC + angle ABC, with a complete argument B1 [3]

Unit 2 · Sheet A — Polygons

- 1 1080°
- 2 1260°
- 3 1800°
- 4 72°
- 5 36°
- 6 108°
- 7 140°
- 8 162°
- 9 18
- 10 12
- 11 8
- 12 120°
- 13 36°
- 14 108°
- 15 16
- 16 no; exterior 50° and $360 \div 50 = 7.2$

Unit 2 · Sheet B — Polygons

- 1 (a) interior angle of octagon = $1080 \div 8 = 135^\circ$ M1; $360 - 135 = 90$ M1; $x = 135^\circ$ A1 [3] (b) $90 + 135 + 135 = 360$ B1 [1]
- 2 (a) sum = 720° B1; $10x + 280 = 720$ M1; $x = 44$ A1 [3] (b) 88° B1 ft [1]
- 3 (a) interior angle 108° , triangle ABE is isosceles ($AB = AE$) M1; $(180 - 108) \div 2 = 36^\circ$ A1 [2] (b) $108 - 36 = 72^\circ$ B1 ft [1] (c) angle BCD = 108° and $72 + 108 = 180$ M1; co-interior angles sum to 180° , so $BE \parallel CD$ A1 [2]
- 4 (a) $e + 8e = 180$ M1; $e = 20^\circ$ A1; $360 \div 20 = 18$ A1 [3] (b) $180 \times (18 - 2)$ M1; 2880° A1 ft [2]
- 5 $360/n - 360/(2n) = 18$ M1; $180/n = 18$ M1; $n = 10$ A1 [3]
- 6 (a) $3y + y + 20 + 2(2y + 10) = 360$ M1; $8y + 40 = 360$ M1; $y = 40$ A1 [3] (b) angles B and D = $2 \times 40 + 10 = 90^\circ$ B1 [1]

Unit 3 · Sheet A — Symmetry and quadrilaterals

- 1 1 line; order 1
- 2 4 lines; order 4
- 3 8 lines; order 8
- 4 1 line; order 1
- 5 0 lines; order 2
- 6 2 lines; order 2
- 7 square
- 8 parallelogram
- 9 kite
- 10 isosceles
- 11 10
- 12 3

Unit 3 · Sheet B — Symmetry and quadrilaterals

1 (a) the four squares reflected in the dashed line B2 (B1 for 2 or 3 correct) **[2]** (b) images of the three squares under a half-turn about the centre of the grid: column 4 row 6, column 3 row 5, column 5 row 4 (counting from top left) B2 (B1 for 2 correct) **[2]**

2 (a) rhombus 2, 2; kite 1, 1; parallelogram 0, 2; isosceles trapezium 1, 1; regular hexagon 6, 6; equilateral triangle 3, 3. B1 each row **[6]**

3 (a) (2, 4) B2 (B1 for D plotted correctly without coordinates) **[2]** (b) 2 B1 **[1]** (c) O B1 **[1]**

4 (a) square; rectangle; rhombus; kite; parallelogram. B1 each **[5]**

5 (a) 54° M1 (opposite angles equal); 126° , 126° A1 **[2]** (b) $360 - 2 \times 112 = 48$ M1; 88° A1 **[2]**

6 (a) rhombus (or square) B1 **[1]** (b) O (e.g. a three-bladed propeller shape) B1 **[1]**

Unit 4 · Sheet A — Measures and unit conversions

- 1** 56
- 2** 72
- 3** 4.25
- 4** 3050
- 5** 0.76
- 6** 80
- 7** 3.5
- 8** 400
- 9** 2.25
- 10** 60 000
- 11** 8.2
- 12** 350
- 13** 500 000
- 14** 1.2
- 15** 7
- 16** 4200
- 17** 0.65
- 18** 2 400 000

Unit 4 · Sheet B — Measures and unit conversions

- 1** (a) $1500 \div 180$ M1; 8 A1 **[2]** (b) $1500 - 8 \times 180 = 60$ ml B1 **[1]**
- 2** (a) $2.4 \times 1.5 \times 0.6$ M1; 2.16 m^3 A1 **[2]** (b) 2160 litres B1 ft **[1]** (c) $2160 \div 18 = 120$ minutes M1; 2 hours A1 **[2]**
- 3** (a) 250×80 M1; $20\,000 \text{ cm}^2$ A1; 2 m^2 B1 **[3]** (b) 45 km^2 B1 **[1]**
- 4** (a) 600 cm^3 B1 **[1]** (b) $20 \text{ cm} \times 12 \text{ cm} \times 8 \text{ cm}$ B1; $(20 \div 4) \times (12 \div 4) \times (8 \div 4)$ M1; 30 A1 **[3]**
- 5** (a) $24 \times 415 = 9960$ g M1; $9.96 + 0.6$ M1; 10.56 kg A1 **[3]** (b) $(12 - 0.6) \div 0.415 = 27.4\ldots$ M1; 27 A1 **[2]**
- 6** (a) $18.6 \div 1.8 = 10.33\ldots$ M1; 11 A1 **[2]** (b) 11×24.50 M1; $\$269.50$ A1 ft **[2]** (c) 18 600 mm B1 **[1]**

Unit 5 · Sheet A — Bearings and scale drawings

- 1** 1.8 km
- 2** 180 m
- 3** 20 m
- 4** 90 km
- 5** 6 cm
- 6** 14 cm
- 7** 045°
- 8** 270°
- 9** 242°
- 10** 025°
- 11** 135°
- 12** 270°
- 13** 148° (accept 146° – 150°)
- 14** 321° (accept 319° – 323°)

Unit 5 · Sheet B — Bearings and scale drawings

- 1** (a) $12\,000 \div 1500 = 8$ cm B1; $7500 \div 1500 = 5$ cm B1 **[2]** (b) accurate 8 cm by 5 cm rectangle; diagonal ≈ 9.4 cm M1; ≈ 142 m (accept 139–143 m) A1 **[2]** (c) 40 cm^2 B1 **[1]**
- 2** (a) AB = 6 cm on bearing 040° B1; BC = 9 cm on bearing 130° B1 **[2]** (b) AC ≈ 10.8 cm M1; 54 km (accept 52–56) A1 **[2]** (c) measures the angle clockwise from North at A M1; 096° (accept $\pm 2^\circ$) A1 **[2]**
- 3** angle RPQ = $90 - 52 = 38^\circ$ M1; angle RQP = $320 - 270 = 50^\circ$ M1; angle PRQ = $180 - 38 - 50 = 92^\circ$ A1; correct reasons B1 **[4]**
- 4** (a) $6.8 \times 50\,000 = 340\,000$ cm M1; 3.4 km A1 **[2]** (b) $3.4 \div 4 \times 60 = 51$ minutes B1 ft **[1]**
- 5** (a) 065° B1 **[1]** (b) $x + 180 = 3x$ M1; $x = 90$ A1; 090° and 270° A1 **[3]**
- 6** $4.2 \times 2 = 8.4$ m and $3.5 \times 2 = 7$ m M1 M1; 58.8 m^2 A1 **[3]**

Unit 6 · Sheet A — Constructions

- 1** 6.4 cm (± 0.2 cm)
- 2** 57° ($\pm 2^\circ$)
- 3** 236° ($\pm 2^\circ$)
- 4** two pairs of equal arcs from A and B; line through both crossing points, at 90° to AB through its midpoint
- 5** arcs as in the worked example; bisector at 35° to each arm ($\pm 2^\circ$)
- 6** arc from A cutting AB; same radius arc from that point; join A to the crossing
- 7** PQ 7 cm; arcs of radius 5 cm from P and 4 cm from Q; sides ± 2 mm
- 8** BC = 4.6 cm (± 0.2 cm)

Unit 6 · Sheet B — Constructions

1 (a) AB = 8 cm B1; angle A = 40° B1; angle B = 65° B1 (all ± 2 mm / 2°) [3] (b) AC = 7.5 cm B1; BC = 5.3 cm B1 (± 0.2 cm) [2] (c) 75° (± 2°) B1 [1]
(d) $8 + 7.5 + 5.3 = 20.8$ cm (ft their measurements) B1 [1]

2 (a) arcs from R cutting PQ twice, then equal arcs from those points B1; correct perpendicular B1 [2] (b) 3.8 cm (± 0.2 cm) B1 [1] (c) $\frac{1}{2} \times 7 \times 3.8$ M1; 13.3 cm² A1 ft [2] (d) PR = 4.5 cm (± 0.2 cm) B1; angle QPR = 57° (± 2°) B1 [2]

3 (a) arc from B cutting both arms, then equal arcs B1; correct bisector B1 [2] (b) 42° (± 2°) B1 [1] (c) 3.3 cm (± 0.2 cm) B1 [1]

4 (a) AC = 8 cm B1; arcs of radius 5 cm from A and C on both sides B1; rhombus completed B1 [3] (b) 6 cm (± 0.2 cm) B1 [1] (c) 106° (± 2°) B1 [1] (d) $\frac{1}{2} \times 8 \times 6 = 24$ cm² B1 ft [1]
(e) 20 cm B1 [1]

Unit 7 · Sheet A — Perimeter and area

- 1 75 cm²
- 2 36 cm²
- 3 91 cm²
- 4 56 cm²
- 5 26 cm
- 6 30 cm
- 7 $36 + 28 = 64$ cm²
- 8 44 cm
- 9 6 cm
- 10 81 cm²
- 11 10 cm
- 12 8 cm

Unit 7 · Sheet B — Perimeter and area

- 1** (a) $15 \times 9 = 135$ M1; $4 \times 2.5 = 10$ M1; 125 m² A1 [3] (b) $125 \times 40 = 5000$ g M1; 5 boxes M1; \$43.75 A1 ft [3] (c) 48 m B1 [1]
2 $\frac{1}{2} \times (7 + 13) \times h = 60$ M1; $10h = 60$ M1; $h = 6$ cm A1 [3]
3 (a) base 6, height 5 M1; 15 cm² A1 [2] (b) $\sqrt{15}$ M1; 3.87 cm A1 [2]
4 (a) $2(2x + 3) + 2(x - 1) = 52$ M1; $6x + 4 = 52$ M1; $x = 8$ A1 [3] (b) $19 \times 7 = 133$ cm² B1 ft [1]
5 $9 \times 6 = 54$ M1; $\frac{1}{2} \times b \times 8 = 54$ M1; $b = 13.5$ cm A1 [3]
6 $4.2 \times 2.6 - 0.9 \times 2 = 9.12$ m² M1; $\times 2 = 18.24$ m² M1; $\div 12 = 1.52$ litres M1; 1 tin A1 [4]

Unit 8 · Sheet A — Circles, arcs and sectors

- 1 50.3 cm
- 2 47.1 cm
- 3 113 cm²
- 4 63.6 cm²
- 5 39.3 cm²
- 6 17.9 cm
- 7 8.38 cm
- 8 31.4 cm²
- 9 46.2 cm
- 10 15.9 cm
- 11 3.99 cm
- 12 95.5°

Unit 8 · Sheet B — Circles, arcs and sectors

- 1** (a) $\pi \times 60 = 188$ M1; 200 + 188 M1; 388 m A1 [3] (b) $100 \times 60 = 6000$ M1; $\pi \times 30^2 = 2830$ M1; 8830 m² A1 [3]
2 (a) $\pi \times 15^2 \div 8$ M1; 88.4 cm² A1 [2] (b) $\pi \times 30 \div 8$ M1; 11.8 cm A1 [2] (c) 41.8 cm B1 ft [1]
3 arc = $80/360 \times 2\pi r$ M1; $2r + (4\pi/9)r = 30$ M1; $r = 30 \div (2 + 4\pi/9)$ M1; 8.83 cm A1 [4]
4 $\pi \times 12^2 - \pi \times 0.3^2$ M2 (M1 for one area); 4.24 cm² A1 [3]
5 sector $120/360 \times \pi \times 81 = 84.8$ M1; triangle $\frac{1}{2} \times 9 \times 9 \times \sin 120^\circ = 35.1$ M1; subtract M1; 49.7 cm² A1 [4]
6 $2 \times \pi \times 34 = 214$ cm M1; $\times 500$ M1; 1.07 km A1 [3]

Unit 9 · Sheet A — Prisms and cylinders

- 1 100 cm³
- 2 $2(40 + 20 + 12.5) = 145$ cm²
- 3 $\frac{1}{2} \times 5 \times 12 \times 9 = 270$ cm³
- 4 $2 \times 30 + (5 + 12 + 13) \times 9 = 330$ cm²
- 5 $200\pi = 628$ cm³
- 6 $80\pi = 251$ cm²
- 7 $72.5\pi = 228$ cm²
- 8 $250\pi = 785$ cm³
- 9 91.125 cm³ (91.1)
- 10 5 cm
- 11 5.15 cm
- 12 148 cm³

Unit 9 · Sheet B — Prisms and cylinders

- 1** (a) $\frac{1}{2} \times 6 \times 4 \times 20$ M1; 240 cm³ A1 [2] (b) $2 \times 12 = 24$ B1; $(5 + 5 + 6) \times 20 = 320$ M1; 344 cm² A1 [3]
2 (a) $\frac{1}{2} \times \pi \times 30^2 \times 200$ M2 (M1 for $\pi \times 30^2 \times 200$ or wrong units); 283000 cm³ M1 ($\div 1000$); 283 litres A1 [4] (b) $60 \times 200 = 12\,000$ cm² B1 [1]
3 (a) $\pi \times 0.8^2 \times 1.5$ M1; 3.02 m³ A1 [2] (b) 3020 litres B1; $\div 20 = 150.8$ minutes M1; 2 hours 31 minutes A1 [3]
4 $\pi r^2 \times 2r = 750$ M1; $r^3 = 750 \div (2\pi)$ M1; 4.92 cm A1 [3]
5 $30 \times 20 \times 10 = 6000$ cm³ M1; $6000 \div (\pi \times 8^2)$ M1; 29.8 cm A1 [3]
6 (a) $1000 = \pi \times 36 \times h$ M1; $h = 1000 \div (36\pi)$ M1; 8.84 cm A1 [3] (b) cube 600 cm²; cylinder $2\pi \times 6 \times 8.84 + 2\pi \times 36 = 560$ cm² M1; the cube A1 [2]

Unit 10 · Sheet A — Pyramids, cones and spheres

- 1 $\frac{1}{3} \times 81 \times 14 = 378$ cm³
- 2 $120\pi = 377$ cm³
- 3 $105\pi = 330$ cm²
- 4 524 cm³
- 5 $100\pi = 314$ cm²
- 6 $144\pi = 452$ cm³
- 7 $27\pi = 84.8$ cm²
- 8 $l = 15$; $135\pi + 81\pi = 216\pi = 679$ cm²
- 9 56 cm³
- 10 4.92 cm
- 11 5.97 cm
- 12 9.85 cm

Unit 10 · Sheet B — Pyramids, cones and spheres

1 cylinder $\pi \times 9 \times 12 = 108\pi$ M1; cone $\frac{1}{3} \times \pi \times 9 \times 4 = 12\pi$ M1; 120π M1; 377 cm^3 A1 [4]

2

(a) $(4/3)\pi \times 27 = 36\pi$ M1; $\frac{1}{3} \times \pi \times 9 \times h = 36\pi$ M1; $h = 12$ cm A1 [3]
(b) $l = \sqrt{(3^2 + 12^2)} = 12.4$ M1; $\pi \times 3 \times 12.4 = 117 \text{ cm}^2$ A1 [2]

3 (a) $\frac{2}{3} \times \pi \times 12^3$ M1; 3620 cm^3 A1; 3.62 litres A1 [3] (b) 14 B1 ft [1]

4 (a) $36 + 4 \times \frac{1}{2} \times 6 \times 5$ M1; 96 cm^2 A1 [2] (b) $\sqrt{(5^2 - 3^2)}$ M1; $= 4$ A1 [2] (c) $\frac{1}{3} \times 36 \times 4 = 48 \text{ cm}^3$ B1 [1]

5 $\frac{1}{3} \times \pi \times 100 \times 30 = 1000\pi$ M1; $\frac{1}{3} \times \pi \times 16 \times 12 = 64\pi$ M1; 936π M1; 2940 cm^3 A1 [4]

6 tube $\pi \times 3.5^2 \times 21 = 808$ M1; balls $3 \times (4/3)\pi \times 3.5^3 = 539$ M1; subtract M1; 269 cm^3 A1 [4]

Unit 11 · Sheet A — Similar shapes

1 $k = 15 \div 6 = 2.5$; $x = 10$ cm

2 $k = 15 \div 5 = 3$; $x = 12$ cm

3 2.5

4 17.5 cm

5 12 cm

6 8 cm

7 4 : 25

8 4

9 108 cm^2

10 2 : 5

11 182.25 cm^3

12 80 cm^2

Unit 11 · Sheet B — Similar shapes

1 (a) angle ACB = angle ECD (vertically opposite) and angle BAC = angle DEC (alternate), so all angles are equal B1 [1] (b) $k = 6 \div 9$ M1; 5 cm A1 [2] (c) BC : CD = 9 : 6, so BC = $12 \times 9/15$ M1; 7.2 cm A1 [2]

2 (a) $12 \div 8 = 1.5$ and $7.5 \div 5 = 1.5$ M1; same scale factor, so similar A1 [2] (b) 2 : 3 B1 [1] (c) 4 : 9 B1 [1]

3 (a) 120×1.5^2 M1; 270 cm^2 A1 [2] (b) $405 \div 1.5^3$ M1; 120 cm^3 A1 [2]

4 (a) $2000 \div 250 = 8$ M1; $k = \sqrt[3]{8} = 2$ M1; 18 cm A1 [3] (b) $180 \div 2^2$ M1; 45 cm^2 A1 [2]

5 $k = 75 \div 30 = 2.5$ M1; 2.4×2.5^3 M1; 37.5 kg A1 [3]

6 (a) $x/(x+4) = 6/10$ M1; $10x = 6x + 24$ M1; $x = 6$ A1 [3] (b) AE : EC = 6 : 4, AE = 7.5 cm B1 [1]

Unit 12 · Sheet A — Circle properties

1 32° (tangent $\perp$ radius; $180 - 90 - 58$)

2 58° (PA = PB so $(180 - 64) \div 2$)

3 56° ($360 - 90 - 90 - 124$)

4 13 cm (AM = 5)

5 AB = 16 cm (AM = 8)

6 PT = 12 cm ($\sqrt{(13^2 - 5^2)}$)

7 130° (isosceles: $180 - 2 \times 25$)

8 56° (angle OAT = 90° ; $90 - 34$)

9 OP = 10 cm ($\sqrt{(8^2 + 6^2)}$)

Unit 12 · Sheet B — Circle properties

1 (a) $\sqrt{(7^2 + 24^2)}$ M1; 25 cm A1 [2] (b) $25 - 7 = 18$ cm B1 ft [1] (c) $\frac{1}{2} \times 7 \times 24$ M1; 84 cm^2 A1 [2]

2 (a) 90° , tangent $\perp$ radius B1 [1] (b) $360 - 90 - 90 - 110$ M1; 70° A1 [2] (c) PA = PB (tangents from a point are equal) M1; $(180 - 70) \div 2 = 55^\circ$ A1 [2]

3 (a) half-chord 9 cm B1; $\sqrt{(9^2 + 5^2)}$ M1; 10.3 cm A1 [3] (b) $2 \times \sqrt{(106 - 64)}$ M1; 13.0 cm A1 [2]

4 (a) chord; tangent; sector; segment. B1 each [4]

5 angle OBA = $2x$ (isosceles, OA = OB) B1; $2x + 2x + 5x + 9 = 180$ M1; $x = 19$ and angle AOB = 104° A1 [3]

6 angle OTP = 90° B1; $3y + 5y + 2 = 90$ M1; $y = 11$, angle TOP = 57° A1 [3]

Unit 13 · Sheet A — Circle theorems

1 74° (angle at centre = $2 \times$ angle at circumference)

2 49° (angle in a semicircle = 90°)

3 29° (angles in the same segment)

4 104° (opposite angles of a cyclic quadrilateral)

5 67° (alternate segment theorem)

6 210° (reflex angle at centre = 2×105)

7 $x = 6$ ($4 \times 9 = 6x$)

8 $x = 2$ ($4 \times 12 = 6 \times PD$, PD = 8)

9 $x = 6$ ($x^2 = 3 \times 12$)

10 $x = 36$

11 98°

12 6 cm

Unit 13 · Sheet B — Circle theorems

1 (a) 116° B1; opposite angles of a cyclic quadrilateral sum to 180° B1 [2] (b) 128° B1; angle at the centre is twice the angle at the circumference B1 [2]

(c) OB = OD M1; $(180 - 128) \div 2 = 26^\circ$ A1 [2]

2 (a) 48° B1; alternate segment theorem B1 [2] (b) $180 - 48 - 70 = 62^\circ$ B1 [1] (c) No: angle BAC = 70° , not 90° (angle in a semicircle would be 90°) B1 [1]

3 CX $\times$ XD = $5 \times 8 = 40$ M1; CX(14 - CX) = 40 M1; $CX^2 - 14CX + 40 = 0$, (CX - 4)(CX - 10) = 0 M1; 4 cm and 10 cm A1 [4]

4 (a) PA $\times$ PB = PC $\times$ PD M1; $5 \times 12 = 6 \times PD$, PD = 10 A1; CD = 4 cm A1 [3] (b) PT² = $5 \times 12 = 60$ M1; 7.75 cm A1 [2]

5 join C (on circumference) through O to a point D on the circle B1; triangles OAC and OBC are isosceles, so angle AOD = $2 \times$ angle OCA (exterior angle) B1; similarly angle BOD = $2 \times$ angle OCB B1; adding gives angle AOB = $2 \times$ angle ACB, with reasons B1 [4]

6 angle ACB = 90° (angle in a semicircle) B1; angle ABC = 55° B1; angle ADC = angle ABC = 55° (angles in the same segment) B1 [3]

Unit 14 · Sheet A — Congruence and geometrical proof

1 congruent, SSS

2 congruent, SAS

3 congruent, ASA

4 congruent, RHS

5 not necessarily congruent (AAA only shows similarity)

6 congruent, AAS

7 no: the third sides are different

8 AAA

Unit 14 · Sheet B — Congruence and geometrical proof

- 1 (a)** $AB = CD$ and $BC = DA$ (opposite sides of a parallelogram) B1; AC common B1; congruent (SSS) B1 (or ASA using alternate angles) [3] **(b)** corresponding angles of congruent triangles are equal B1 [1]
- 2** $AB = AC$ (given), $BM = CM$ (M is the midpoint), AM common B1 B1; congruent (SSS) B1; angle $AMB =$ angle AMC and they add to 180° , so each is 90° B1 [4]
- 3** $AB = BC$ (sides of a square) B1; angle $ABE =$ angle $BCF = 90^\circ$ B1; $BE = CF$ (given), so triangles ABE and BCF are congruent (SAS) B1; hence $AE = BF$ B1 [4]
- 4** $AX = XB$ and $CX = XD$ (bisect each other) B1; angle $AXC =$ angle BXD (vertically opposite) B1; triangles AXC and BXD congruent (SAS), so $AC = BD$ B1; angle $CAX =$ angle DBX , alternate angles equal so $AC \parallel DB$ B1 [4]
- 5 (a)** two angles at A equal to angle B and angle C (alternate angles) B1 B1; the three angles at A lie on a straight line so sum to 180° B1 [3] **(b)** a diagonal splits the quadrilateral into two triangles M1; $2 \times 180 = 360^\circ$ A1 [2]
- 6 (a)** $AB = AD$, $CB = CD$ (given), AC common B1; triangles ABC and ADC congruent (SSS) B1; so angle $BAC =$ angle DAC B1 [3] **(b)** corresponding angles of the congruent triangles are equal B1 [1]

End-of-book check

- 1** 122° (co-interior angles sum to 180°)
- 2** 144°
- 3** 120°
- 4** 154 cm^2
- 5** 42.4 cm^2
- 6** 52 cm^2
- 7** 264 cm^3
- 8** 78.5 cm^2
- 9** 20 cm
- 10** 1 : 9
- 11** 70°
- 12** 8 cm

Practice paper

- 1 (a)** $a = 117^\circ$ B1; angles on a straight line / co-interior angles B1 [2] **(b)** $b = 117^\circ$ B1; vertically opposite to a (or corresponding angles) B1 [2]
- 2 (a)** exterior angle 24° M1; $360 \div 24$ M1; 15 A1 [3] **(b)** 2340° B1 ft [1]
- 3 (a)** 033° B1 [1] **(b)** $9.6 \times 20\,000 = 192\,000 \text{ cm}$ M1; 1.92 km A1 [2] **(c)** angle $RPQ = 90 - 40 = 50^\circ$ and angle $RQP = 320 - 270 = 50^\circ$ M1; two equal angles, so isosceles A1 [2]
- 4 (a)** two pairs of equal arcs B1; correct line B1 [2] **(b)** 4 cm (± 0.2 cm) B1 [1]
- 5 (a)** $10 \times 6 = 60$ B1; $\frac{1}{2} \times 10 \times 4 = 20$ M1; 80 cm^2 A1 [3] **(b)** $10 + 6 + 6 + 6.4 + 6.4$ M1; 34.8 cm A1 [2]
- 6 (a)** $\frac{1}{2} \times \pi \times 7^2$ M1; 77.0 cm^2 A1 [2] **(b)** $\pi \times 7 + 14$ M1; 36.0 cm A1 [2]
- 7 (a)** $72/360 \times 2\pi \times 10$ M1; 12.6 cm A1 [2] **(b)** $72/360 \times \pi \times 10^2$ M1; 62.8 cm^2 A1 [2]
- 8 (a)** $\frac{1}{2} \times 6 \times 8 = 24$ M1; $\times 15 = 360 \text{ cm}^3$ A1 [2] **(b)** $2 \times 24 = 48$ B1; $(6 + 8 + 10) \times 15 = 360$ M1; 408 cm^2 A1 [3]
- 9** cylinder $\pi \times 16 \times 10 = 160\pi$ M1; hemisphere $\frac{2}{3} \times \pi \times 64$ M1; add M1; 637 cm^3 A1 [4]
- 10 (a)** $k = 10 \div 4 = 2.5$ M1 M1; 12.5 cm A1 [3] **(b)** 8×2.5^2 M1; 50 cm^2 A1 [2]
- 11 (a)** 90° , tangent $\perp$ radius B1 [1] **(b)** $360 - 90 - 90 - 52$ M1; 128° A1 [2]
- 12 (a)** 62° B1; opposite angles of a cyclic quadrilateral sum to 180° B1 [2] **(b)** 124° B1; angle at the centre is twice the angle at the circumference B1 [2]
- 13** $PA \times PB = PC \times PD$ M1; $4 \times 9 = 3 \times PD$, $PD = 12$ A1; $CD = 9$ cm A1 [3]
- 14** angle $BAM =$ angle CDM (alternate) B1; angle $ABM =$ angle DCM (alternate) B1; $AB = CD$ so triangles ABM and DCM are congruent (ASA) B1; so $AM = MD$ B1 [4]
- 15 (a)** 2500 litres B1 [1] **(b)** 4.5 m^2 B1 [1] **(c)** 750 000 mm B1 [1]