Cambridge IGCSE · Mathematics 0580 · Notes

Angles

Read online at **pastopic.com/cambridge/mathematics-0580/notes/angles**

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Read first: **Geometrical terms and symmetry**, **Equations and changing the subject**

What you need to know

By the end of this topic you should be able to:

1. **Work out unknown angles using four basic facts**, and give each fact as a reason: angles at a point add up to 360°; angles on a straight line add up to 180°; vertically opposite angles are equal; the angles of a triangle add up to 180° and the angles of a quadrilateral add up to 360°.
2. **Work out unknown angles where a line crosses parallel lines**, and give the reason: corresponding angles are equal, alternate angles are equal, and co-interior angles add up to 180°.
3. **Use the angle facts of regular polygons**: the exterior angle, the interior angle and the sum of the interior angles, including finding the number of sides from an angle. **Extended only:** use the angle sum and exterior angles of irregular polygons too. The syllabus lists this for Extended, but a Core paper has asked it as well (**0580/32/F/M/25 Q21**, an irregular pentagon), so Core students should learn it too.
4. **Read three-letter angle names** such as angle ABC, and use the correct geometrical words when a question asks for a reason.

Understand it

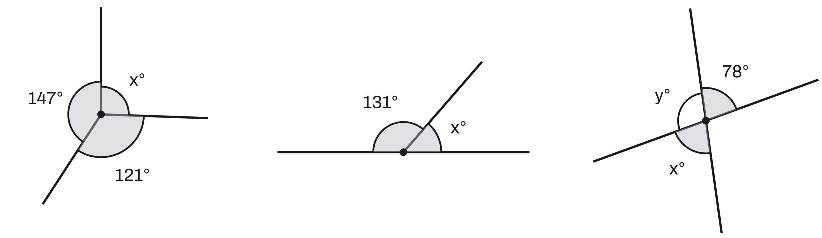
Naming an angle

Angle ABC (also written $\angle ABC$ or $A\hat{B}C$) is the angle at the **middle** letter, B, between the lines BA and BC. So angle DCB is at C, and angle CAB is at A. When a question says "find angle PQR", find one angle at Q, not all three angles of a triangle.

Angles in a diagram are often letters such as x°. Then the answer is just the number: if $x^\circ = 49^\circ$, write $x = 49$.

"NOT TO SCALE" means you cannot measure. Work the angle out from facts, and never assume two angles are equal, or a triangle is isosceles, just because it looks that way.

Angles at a point, on a straight line, vertically opposite



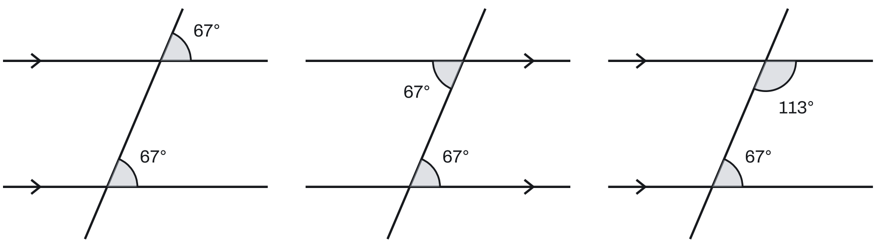
at a point: add up to 360° on a straight line: add up to 180° vertically opposite: equal

- **Angles at a point add up to 360°**: a full turn. In the left diagram, $x = 360 - 147 - 121 = 92$.
- **Angles on a straight line add up to 180°**: half a turn. In the middle diagram, $x = 180 - 131 = 49$.
- **Vertically opposite angles are equal.** Where two straight lines cross they make an X; the angles facing each other across the crossing are equal. In the right diagram $x = 78$, and $y = 180 - 78 = 102$ (on a straight line with the 78°).

Why are vertically opposite angles equal? Each of them makes 180° with the same angle y, so both are $180 - y$.

Angles in parallel lines

When a straight line crosses two parallel lines (marked with matching arrows), it crosses each one at the same slope. So the four angles at one crossing are copied exactly at the other.

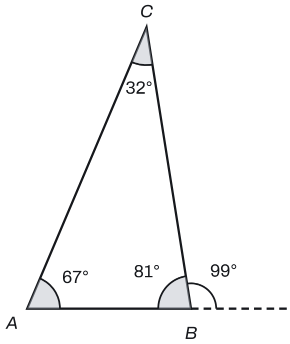


corresponding: equal alternate: equal co-interior: add up to 180°

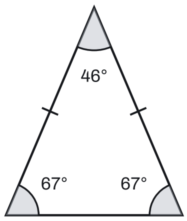
- **Corresponding angles are equal.** They sit in the **same position** at each crossing (both above the line and to the right, say). The pair makes an F shape.
- **Alternate angles are equal.** They are **between** the parallel lines, on **opposite sides** of the crossing line. The pair makes a Z shape.
- **Co-interior angles add up to 180°.** They are **between** the parallel lines, on the **same side** of the crossing line. The pair makes a C (or U) shape. At one crossing the angle is 113°; at the other, the corresponding angle is also 113°, and it sits on a straight line with the 67°, so $113 + 67 = 180$.

The letters F, Z and C only help you spot the pair. In an answer, always write the proper name: "alternate angles", not "Z angles".

Angles in a triangle



67° + 81° + 32° = 180°; exterior 99° = 67° + 32°



equal sides → equal base angles

- **The angles of a triangle add up to 180°.** On the left, the angle at C is $180 - 67 - 81 = 32^\circ$.
- **The exterior angle of a triangle** (one side extended) equals the sum of the two interior angles **not** next to it: $99 = 67 + 32$. This is a shortcut; it comes from the straight line ($180 - 81 = 99$) and the triangle ($67 + 32 = 180 - 81$).
- **Isosceles triangle:** two equal sides (marked with dashes), and the two angles **opposite** those sides, the base angles, are equal. If the angle between the equal sides is 46°, each base angle is $(180 - 46) \div 2 = 67^\circ$. If you know one base angle, the other is the same and the third angle is 180 minus twice it.
- **Equilateral triangle:** all sides equal, all angles 60°.
- **Right-angled triangle:** one angle is 90°, so the other two add up to 90°.

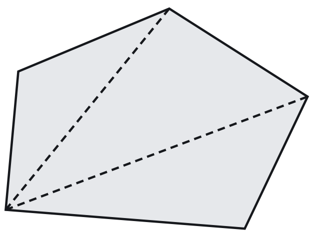
Why do the angles of a triangle add up to 180°? Draw a line through the top vertex parallel to the base. The two base angles appear again at the top as alternate angles, and together with the top angle they make a straight line.

Angles in a quadrilateral

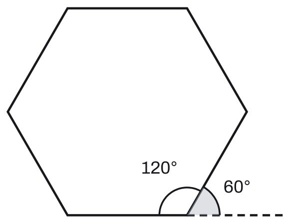
Any quadrilateral splits into 2 triangles by a diagonal, so **its angles add up to** $2 \times 180 = 360^\circ$. In a **parallelogram** the opposite angles are equal and the angles next to each other (co-interior, between the parallel sides) add up to 180°. A **rhombus** is a parallelogram, so the same is true. A **kite** has one pair of equal opposite angles.

A quadrilateral can have a **reflex** interior angle (more than 180°). The four angles still add up to 360°.

Polygons: angle sum, interior and exterior angles



3 triangles: 3 × 180° = 540°



exterior 360° ÷ 6 = 60°; interior 120°

Angle sum. From one vertex of a polygon with n sides you can draw diagonals that split it into $n-2$ triangles. So the interior angles add up to

$$(n-2) \times 180^\circ.$$

A pentagon ($n=5$) has $3 \times 180 = 540^\circ$; a hexagon has $4 \times 180 = 720^\circ$.

Exterior angles. Extend each side in turn. Walking once round the polygon you turn through every exterior angle and end up facing the way you started: one full turn. So the **exterior angles of any polygon add up to** 360°. At each vertex,

$$\text{interior angle} + \text{exterior angle} = 180^\circ$$

because they lie on a straight line.

Regular polygons have all sides and all angles equal, so each exterior angle is $360^\circ \div n$, and each interior angle is 180° minus that. A regular hexagon: exterior $360 \div 6 = 60^\circ$, interior $180 - 60 = 120^\circ$. Check: $6 \times 120 = 720$, the angle sum.

Number of sides. Turn it round: $n = 360 \div \text{exterior angle}$. If you are given the interior angle, find the exterior angle first. A regular polygon with interior angle 157.5° has exterior angle 22.5°, so $n = 360 \div 22.5 = 16$. The answer must be a whole number: if it is not, recheck your working.

Extended only (in the syllabus, though Core has asked it too, in **0580/32/F/M/25 Q21**): for an irregular polygon the angles are not all equal, but the angle sum $(n-2) \times 180$ and the exterior-angle total 360° still hold. That is how you set up an equation when the angles are given as expressions or in a ratio.

Reasons

Many questions say "Give a geometrical reason". A reason is the **fact** you used, in words, with its key words:

You used	Write
a full turn	angles at a point add up to 360°
half a turn	angles on a straight line add up to 180°
the X of two crossing lines	vertically opposite angles are equal
a triangle	angles in a triangle add up to 180°
two equal sides	base angles of an isosceles triangle are equal
a quadrilateral	angles in a quadrilateral add up to 360°
an F pair	corresponding angles are equal
a Z pair	alternate angles are equal
a C pair	co-interior angles add up to 180°

Key facts and formulas

None of these is on the List of formulas printed on page 2 of the exam paper, so learn them all.

Formula	Status
Angles at a point add up to 360°	Learn it
Angles on a straight line add up to 180°	Learn it
Vertically opposite angles are equal	Learn it
Angles in a triangle add up to 180°; exterior angle of a triangle $=$ sum of the two opposite interior angles	Learn it
Base angles of an isosceles triangle are equal; each angle of an equilateral triangle is 60°	Learn it
Angles in a quadrilateral add up to 360°	Learn it
Parallel lines: corresponding angles equal, alternate angles equal, co-interior angles add up to 180°	Learn it
Sum of the interior angles of an n-sided polygon $= (n-2) \times 180^\circ$	Learn it
Sum of the exterior angles of any polygon $= 360^\circ$	Learn it
Interior angle $+$ exterior angle $= 180^\circ$	Learn it
Regular polygon: exterior angle $= \dfrac{360^\circ}{n}$, interior angle $= 180^\circ - \dfrac{360^\circ}{n}$	Learn it
Number of sides of a regular polygon: $n = \dfrac{360^\circ}{\text{exterior angle}}$	Learn it

Regular polygon	n	Angle sum	Exterior	Interior
equilateral triangle	3	180°	120°	60°
square	4	360°	90°	90°
pentagon	5	540°	72°	108°
hexagon	6	720°	60°	120°
octagon	8	1080°	45°	135°
decagon	10	1440°	36°	144°

How to do it

In the questions we have tagged for this topic (110 questions, 2021–2025, of which 96 are different: 13 questions were printed on more than one paper, 12 of them on two papers and one on three), the types came up this often. 62 of the 110 questions mix more than one type, so the counts add up to more than 110.

Question type	Questions
Polygons: interior and exterior angles, angle sum, number of sides	42
Triangles, including isosceles and equilateral	41
Angles at a point, on a straight line, vertically opposite	32
Angles in parallel lines	27
Quadrilaterals, including parallelograms and rhombuses	21
Giving a geometrical reason	20
Forming and solving an equation (algebra or ratio)	18

1. Polygons: interior and exterior angles, angle sum, number of sides (42 questions)

1. **Interior angle of a regular n-sided polygon**: exterior $= 360 \div n$, then interior $= 180-$ exterior. Or: angle sum $(n-2) \times 180$, then divide by n. Both score.
2. **Number of sides from an angle**: get the exterior angle ($180-$ interior, if you are given the interior), then $n = 360 \div \text{exterior}$. Interior 168° gives exterior 12° and $n = 30$.
3. **Angle sum**: $(n-2) \times 180$. Then use it like a triangle's 180: add the known angles and subtract from the total.

Variations you will meet:

- **"Show that the interior angle of a regular … is …"**: write every step with numbers, such as $360 \div 5 = 72$ then $180 - 72 = 108$, or $(5-2) \times 180 = 540$ then $540 \div 5 = 108$. Don't start from the answer.
- **A line of symmetry through a vertex** of a regular polygon cuts that interior angle exactly in half.
- **Regular polygons meeting at a point**, or sharing a side: the angles at the shared point add up to 360°. Two polygons sharing one side and one vertex: the angle between their other sides is the difference (or the sum) of their interior angles.
- **Interior and exterior in a ratio, or one given as a multiple of the other**: call the exterior angle e; then interior $+$ exterior $= 180$ gives an equation. "Interior is 7 times exterior": $7e + e = 180$, so $e = 22.5$ and $n = 16$.
- **Interior and exterior as expressions** (such as $(ax+b)^\circ$ and $(cx+d)^\circ$): add them, set equal to 180, solve for x, work out the exterior angle, then $n = 360 \div \text{exterior}$.
- **Angles of an irregular polygon as expressions or in a ratio** (Extended in the syllabus, but asked on both tiers: Core 0580/32/F/M/25 Q21, Extended 0580/21/M/J/22 Q12): set their sum equal to $(n-2) \times 180$. For a ratio, divide the angle sum by the total number of parts.

- **"Write down two properties that show a polygon is regular"**: all sides equal and all angles equal.

2. Triangles, including isosceles and equilateral (41 questions)

1. **Mark every angle you know** on the diagram, and look for equal-side marks.
2. **Isosceles**: the two angles opposite the equal sides are equal. Decide which angle is the odd one out (the one between the equal sides) before you calculate.
3. **Use** 180°: third angle $= 180-$ the other two; for isosceles with the top angle known, each base angle $= (180 - \text{top}) \div 2$; with a base angle known, top $= 180 - 2 \times \text{base}$.

Variations you will meet:

- **A side extended** (a straight line through a vertex): first use angles on a straight line to get the interior angle, then the triangle.
- **An equilateral triangle** inside another shape: each angle is 60°.
- **Two triangles sharing a side**, or a small triangle inside a bigger one: work one triangle at a time, writing each angle you find on the diagram.
- **"Explain why this triangle is scalene"**: find the third angle; all three angles are different, so all three sides are different.
- **Show that the mean of the angles in any triangle is** 60°: $180 \div 3 = 60$.
- **Angles in a ratio**, such as $2:3:4$: there are 9 parts, $180 \div 9 = 20$, so the angles are 40°, 60° and 80°.

3. Angles at a point, on a straight line, vertically opposite (32 questions)

1. **Spot the shape**: lines meeting at one point all round (360°), one line standing on a straight line (180°), or two straight lines crossing (vertically opposite, equal).
2. **Subtract the known angles** from 360 or 180, or copy the opposite angle.
3. These are usually one step in a longer chain: find this angle first, then use it in a triangle or quadrilateral.

Variations you will meet:

- **A reflex angle** at a point: the reflex angle and the angle inside the shape add up to 360°.
- **Equal angles at a point**, marked with the same letter: 9 equal angles round a point are each $360 \div 9 = 40^\circ$.
- **Angles given as expressions** on a straight line: add them and set equal to 180.

4. Angles in parallel lines (27 questions)

1. **Find the parallel lines** (the arrows) and the line crossing them.
2. **Find the pair**: same position at each crossing is **corresponding** (equal); between the lines on opposite sides is **alternate** (equal); between the lines on the same side is **co-interior** (add up to 180°).
3. If the angle you want is not in a pair with a known angle, first move along a straight line (180) or across an X (vertically opposite), then use the parallel lines.

Variations you will meet:

- **Two crossing lines** that meet on one of the parallel lines make a triangle with the other: use alternate angles to copy angles into the triangle, then use 180°.
- **Two pairs of parallel lines**: go one pair at a time.
- **"Complete the statement: angle A and angle ... are corresponding angles"**: name the angle in the same position at the other crossing.
- **Parallelograms and trapeziums**: their parallel sides give co-interior angles that add up to 180°.

5. Quadrilaterals, including parallelograms and rhombuses (21 questions)

1. The four angles add up to 360°: subtract the known ones.
2. If a side is extended, get the interior angle from the straight line first.
3. **Parallelogram or rhombus**: opposite angles are equal and neighbouring angles add up to 180°. One angle gives all four.

Variations you will meet:

- **A reflex angle given at a vertex** (such as the outside angle at D): the interior angle is 360 minus it.
- **Parallelogram with angles as expressions**: two neighbouring angles add up to 180; two opposite angles are equal. With $(2x + 11)^\circ$ and $(3x + 4)^\circ$ as neighbours, $5x + 15 = 180$, so $x = 33$ and the angles are 77° and 103°.
- **A rhombus with neighbouring angles as expressions**, such as a° and $3a^\circ$: $4a = 180$, so $a = 45$.
- **A quadrilateral with one angle in a ratio to the other three**: the parts share 360°.

6. Giving a geometrical reason (20 questions)

1. Work out the angle first.
2. Write the **fact**, not the calculation: "alternate angles are equal", "angles on a straight line add up to 180°". Use the table in Understand it.
3. If two facts are needed, give both, each tied to the angle it finds.

Variations you will meet:

- **"Write down the geometrical reason why x is ..."**: one fact, the one that gives x directly.
- **"Give two geometrical reasons"**: typically one fact to find an angle in a triangle and one for the straight line; list them in the order you used them.
- **"Explain why [someone] is wrong"**: say which fact their answer breaks, such as "angles in a triangle add up to 180°, but these three add up to 185°".

7. Forming and solving an equation (algebra or ratio) (18 questions)

1. **Choose the fact** that links the angles: sum to 180 (straight line, triangle, co-interior, interior + exterior), sum to 360 (point, quadrilateral), or equal (vertically opposite, alternate, corresponding, base angles).

2. **Write the equation** in full, such as $(x+17)+2x+(3x-9)+136=360$, then collect terms and solve.
3. **Substitute back** to find the angle actually asked for (the largest angle, the smallest angle, the number of sides).

Variations you will meet:

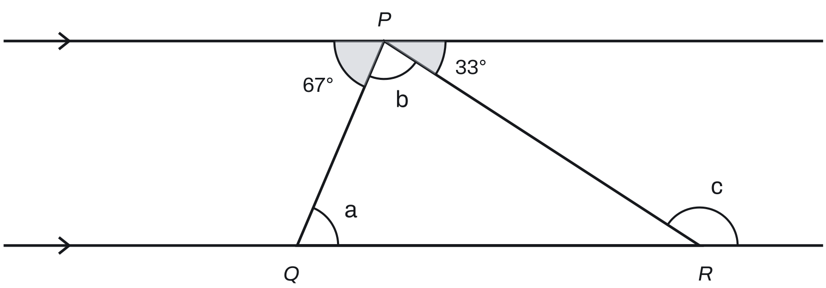
- **Angles in a ratio**: total $\div$ number of parts, then multiply.
- **Simultaneous equations** from two facts (for example a triangle and a straight line): write both equations, then solve together.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1



The diagram shows two parallel lines. P is on one line; Q and R are on the other.

(a) Find the value of a. Give a geometrical reason for your answer. **[2]**

(b) Find the value of b. Give a geometrical reason for your answer. **[2]**

(c) Find the value of c. Give a geometrical reason for your answer. **[2]**

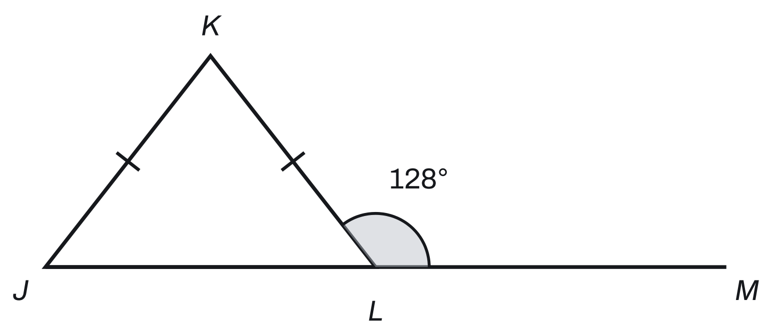
(a) The 67° at P and angle a are between the parallel lines on opposite sides of PQ: $a = 67$ **B1**, alternate angles are equal **B1**.

(b) At P the three angles 67°, b° and 33° lie on the straight line: $b = 180 - 67 - 33 = 80$ **B1**, angles on a straight line add up to 180° **B1**.

(Or: the angle at R inside the triangle is 33° (alternate angles), and $b = 180 - 67 - 33 = 80$ by the angles in triangle PQR.)

(c) The 33° at P and angle c are between the parallel lines on the same side of PR: $c = 180 - 33 = 147$ **B1**, co-interior angles add up to 180° **B1**.

Example 2



JLM is a straight line and $JK = KL$. Angle $KLM = 128^\circ$.

(a) Find angle KLJ. **[1]**

(b) Find angle JKL. **[2]**

(c) Explain why triangle JKL is not equilateral. **[1]**

(a) Angles on a straight line: angle $KLJ = 180 - 128 = 52^\circ$. **B1**

(b) $JK = KL$, so the angles opposite these sides, at L and at J, are equal: angle $KJL = 52^\circ$. **M1** for $180 - 2 \times 52$. Angle $JKL = 180 - 104 = 76^\circ$. **A1**

(c) An equilateral triangle has every angle 60°, but this one has angles 52°, 52° and 76°. **B1**

Example 3

The four angles of a quadrilateral are $(x + 17)^\circ$, $2x^\circ$, $(3x - 9)^\circ$ and 136°.

(a) Write an equation in x and solve it. **[3]**

(b) Find the size of the smallest angle of the quadrilateral. **[1]**

(a) Angles in a quadrilateral add up to 360°:

$$(x + 17) + 2x + (3x - 9) + 136 = 360$$

M1 Collect: $6x + 144 = 360$, so $6x = 216$ **M1**, $x = 36$. **A1**

(b) The angles are $36+17=53^\circ$, $2\times 36=72^\circ$, $3\times 36-9=99^\circ$ and 136° (check: $53+72+99+136=360$). Smallest: 53°. **B1**

Example 4

(a) Work out the size of one interior angle of a regular polygon with 30 sides. **[2]**

(b) Each interior angle of a regular polygon is 7 times its exterior angle. Find the number of sides. **[3]**

(c) *Irregular polygon (Extended in the syllabus; Core has asked it too).* The interior angles of a hexagon are x°, $(x+10)^\circ$, $(x+20)^\circ$, $(x+30)^\circ$, $(x+40)^\circ$ and $(x+50)^\circ$. Find the largest angle. **[3]**

(a) Exterior angle $=360\div 30=12^\circ$ **M1**. Interior $=180-12=168^\circ$. **A1**

(b) Let the exterior angle be e°. Interior $+$ exterior $=180$: $7e+e=180$ **M1**, so $e=22.5$ **A1**. $n=360\div 22.5=16$. **A1**

(c) Angle sum of a hexagon $=(6-2)\times 180=720^\circ$. **B1** $6x+150=720$ **M1**, so $x=95$ and the largest angle is $95+50=145^\circ$. **A1**

Common mistakes

- **Nicknames instead of reasons.** "Z angles", "F angles", "alt", "alternative angles" and "parallel lines" do not score: write "alternate angles" and "corresponding angles" in full. Reports also see "alternate segment theorem" (a circle fact) written for alternate angles.
- **A reason missing its key words.** "On a straight line" or "angles add to 180" is not enough: write "angles on a straight line add up to 180°".
- **The right angle, the wrong reason.** Giving corresponding angles for an alternate pair, or adding extra facts that do not apply, loses the reason mark. Name the one fact you used.
- **Using 180° for angles at a point.** A full turn is 360°.
- **Assuming a triangle is isosceles** because it looks like it. Use equal-side marks or information in the question only.
- **Picking the wrong equal angles in an isosceles triangle.** The equal angles are opposite the equal sides; the angle between the equal sides is the odd one.
- **Stopping at the exterior angle.** When the question asks for the interior angle, remember the last step: $180-$ exterior.
- **Interior $+$ exterior $=360$.** They lie on a straight line, so they add up to 180.
- **Misremembering the angle sum**, such as $n\times 180$ or $(n-1)\times 180$. Picture the triangles: an n-sided polygon has $n-2$.
- **Dividing by the interior angle.** $n=360\div\text{exterior}$, never $360\div\text{interior}$.
- **Reading angle DCB as three angles.** It is one angle, at C.
- **Weak "show that" working.** "3×180" alone does not show where the 3 came from; write $(5-2)\times 180=540$.

How to get the marks

- **"Find"** or **"Work out"**: show the sum you did, such as $(180 - 46) \div 2$. A wrong final answer can still earn the method mark if the method is there.
- **Write angles on the diagram** as you find them. Mark schemes often give a mark for a correct angle "correctly placed on the diagram", even when the final answer is wrong.
- **"Give a geometrical reason"**: the reason mark is separate from the value mark. Use the exact wording from the table in Understand it.
- **"Show that"**: every step must be written with numbers, leading to the given value. The given answer is not enough.
- **Algebra questions** ("write an equation and solve it"): write the full equation first, one mark is usually for that alone; then collect terms and solve.
- **Number of sides**: the answer must be a whole number. If you get a decimal, check whether you used the interior angle where you needed the exterior.
- **Answer the question asked**: the largest angle, not x; angle CAB, not angle ACB.
- Angles are exact whole numbers or simple decimals here; no rounding is needed.

Quick check

1. Three angles at a point are 141°, y° and $2y^\circ$. Find y.
2. A straight line crosses two parallel lines. One of a pair of co-interior angles is 101°. Find the other, and name the fact.
3. In an isosceles triangle the angle between the two equal sides is 134°. Find each of the other two angles.
4. The exterior angle of a regular polygon is 9°. Find the number of sides and the interior angle.
5. *Irregular polygon (Extended in the syllabus; Core has asked it too).* The interior angles of a pentagon are in the ratio $2:3:4:4:5$. Find the largest angle.

Answers

1. Angles at a point add up to 360°: $141 + 3y = 360$, $3y = 219$, $y = 73$.
2. Co-interior angles add up to 180°: $180 - 101 = 79^\circ$.
3. The other two are the base angles, which are equal: $(180 - 134) \div 2 = 23^\circ$ each.
4. $n = 360 \div 9 = 40$ sides; interior angle $= 180 - 9 = 171^\circ$.
5. Angle sum $= (5 - 2) \times 180 = 540^\circ$. Parts: $2 + 3 + 4 + 4 + 5 = 18$; one part $= 540 \div 18 = 30^\circ$. Largest $= 5 \times 30 = 150^\circ$.

Past questions to try

- **0580/11/M/J/25 Q18**: parallel lines with reasons, then a triangle.
- **0580/22/O/N/25 Q6**: a quadrilateral with a parallel line and an isosceles triangle.
- **0580/12/O/N/25 Q14**: a triangle inside a triangle, step by step.
- **0580/22/F/M/25 Q10**: three regular polygons meeting at a point, with interior angles in a ratio.