From 180° to Any Polygon

Teacher		**Class**	Year 9
Subject	Maths	**Topic**	Angles in polygons
Date		**Room**	
Lesson length	60 minutes	**Country**	United Kingdom

Students derive the polygon angle rule from triangles. They use it to find missing and regular polygon angles.

Curriculum links

- Interior/Exterior Angles of Regular/Irregular Polygons [2]

Learning objectives

- Students will derive triangle sum and extend it to any polygon.
- Students will use (n-2) x 180° to find missing interior angles.
- Students will derive regular polygon properties using 360° ÷ n.

Success criteria

- I can explain why the total is (n-2) x 180°.
- I can find a missing angle in any polygon.
- I can find interior and exterior angles of regular polygons.

What students already know

Ask: what do angles on a straight line add to? What do angles in any triangle add to? Show two triangles to check 180°.

Key words

interior angle	size of a corner inside a shape [4]
exterior angle	size of the turn outside a shape when one side is extended [4]
regular polygon	closed straight-sided shape where all edges and corners match [4]
irregular polygon	closed straight-sided shape where edges or corners differ [4]
diagonal	straight join between two corners that are not next to each other
angle sum	total found by adding all the corners together [8]

Materials

- Slides 1-9, 10, 12
- Video clip 1 Triangle split to (n-2) x 180 (0:00-5:00) on slide 6
- printed quadrilateral, pentagon and hexagon outlines
- whiteboard
- mini-whiteboards and pens
- rulers and pencils

Before the lesson

- Print quadrilateral, pentagon and hexagon outlines, one set per pair, with one set pre-marked from one vertex for support.
- Load Slides 1-10 and 12 and test Video clip 1 (0:00-5:00) on slide 6 with sound.
- Draw table headings: sides | triangles | total, and set out whiteboard for class table.

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Lesson outline

0–8 min **Starter** 8 min · Whole class

Recall triangle sum and hook students into splitting polygons into triangles.

YOU DO

1. Show Slide 1 title and Slide 2 objectives and read the two success lines with the class.
2. Say the hook: If one triangle is worth 180°, how many triangles can we hide inside a hexagon?
3. Show Slide 5 question and give 2 minutes think, pair, share.
4. Take answers and confirm a quadrilateral is two triangles joined, so 2 x 180° = 360° [11].

STUDENTS DO

1. Listen to objectives and repeat the hook question in own words to partner.
2. Discuss Slide 5 question in pairs and sketch the two-triangle split.
3. Share ideas and note that triangle corners add to 180° [3].

Say: Today we prove why triangles total 180° and use that to crack any polygon. Look at the quadrilateral question. Talk to your partner and be ready to explain why two triangles must mean 360°.

Worked example: Quadrilateral split from one corner makes 2 non-overlapping triangles. Each triangle totals 180° [3]. Total = 2 x 180° = 360°, which matches the known quadrilateral total of 360° [11].

Ask: What do the three corners of any triangle add to? (180° [3].) · If a quadrilateral is two triangles joined, what must its total be? (2 x 180° = 360° [11].)

Check understanding: Mini-whiteboards up with triangle total and quadrilateral total. Re-teach straight-line idea if any show other than 180° and 360°.

Support: Show a paper quadrilateral cut into two triangles to see the two 180° blocks. **Stretch:** Ask what total they would get by joining two triangles edge to edge and to justify it.

Use: Slides 1-2, Slide 5

8–20 min **Teaching** 12 min · Whole class

Model how splitting from one vertex gives sides minus two triangles.

YOU DO

1. Show Slide 3 steps and model tearing corners idea: three corners fit to a straight line, so 180°.
2. Play Video clip 1 (0:00-5:00) on Slide 6 and ask students to spot how each new side adds one triangle.
3. On the whiteboard draw diagonals from one vertex for quadrilateral to 2 triangles and pentagon to 3 triangles and 540° [3].
4. Record that number of triangles is two fewer than sides and total is triangles x 180°.

STUDENTS DO

1. Watch Video clip 1 and note when the count goes up by one triangle.
2. Copy the quadrilateral and pentagon splits and totals into books.
3. Chant the pattern: sides, triangles, total.

Say: We always split from one corner so triangles do not overlap. Count the triangles, then multiply by 180°. Watch the video to catch why we always subtract two before multiplying.

Worked example: Pentagon from one vertex: draws 2 diagonals to make 3 triangles. Sum = 3 x 180° = 540°, whether regular or irregular [3]. General rule: SUM OF INTERIOR ANGLES = 180° x (n - 2) because the shape splits into n-2 triangles [8].

Ask: Why do we draw all diagonals from one vertex? (To make non-overlapping triangles with no gaps or overlaps.) · A pentagon makes how many triangles and what total? (3 triangles, 3 x 180° = 540° [3].) · How many triangles will a hexagon hide? (4 triangles, so 720° [3].)

Check understanding: Thumbs up for pentagon total 540°. Redraw split slowly if unsure, then cold-call triangle count for hexagon.

Support: Keep a labelled quadrilateral split on the board and point to each 180° block while multiplying.
Stretch: Ask students to predict the rule in words before it is written as (n-2) x 180°.

Use: Slides 3, 6, Video clip 1 (0:00–5:00)

20–38 min **Main activity** 18 min · Pairs

Derive the interior angle sum rule by splitting polygons into triangles.

YOU DO

1. Hand out printed quadrilateral, pentagon and hexagon outlines and rulers.
2. Direct pairs to draw all diagonals from one vertex, count triangles and complete the sides-triangles-total table.
3. Build the class table on the whiteboard: 4 sides gives 2 and 360°, 5 gives 3 and 540° [3], 6 gives 4 and 720° [3].
4. Guide the class to generalise to sum = (n-2) x 180°, where n is sides, and show Slide 7 examples.

STUDENTS DO

1. Draw diagonals from one vertex to split each outline into non-overlapping triangles.
2. Complete the table of number of sides, number of triangles and angle sum and state the pattern in words.
3. Compare with another pair and agree the (n-2) x 180° rule.

Say: Your goal is to derive the rule for the sum of interior angles in any polygon. Split each shape from one corner only, count the hidden triangles, work out the total, then tell me the pattern for any number of sides.

Worked example: Hexagon: from one vertex draw 3 diagonals to make 4 triangles. Total = 4 x 180° = 720° [3]. Table shows 6 - 2 = 4, so for n sides total = (n - 2) x 180°. Nonagon check: (9 - 2) x 180° = 7 x 180° = 1260°.

Ask: How many triangles fit in your hexagon and how do you know? (4 triangles, drawn from one vertex with no overlap, so 4 x 180° = 720° [3].) · What links number of sides to number of triangles? (Triangles are always two fewer than sides, n-2.)

Check understanding: Check tables for 2, 3, 4 triangles and totals 360°, 540°, 720°. If diagonals cross inside, model one-vertex method again.

Support: Provide the shapes with one starting vertex marked and the table headings already drawn. **Stretch:** Ask them to explain in writing why the number of triangles is always two fewer than the number of sides.

Use: Slide 7

38–52 min **Practice** 14 min · On their own

Use sums to find missing angles and regular polygon interior and exterior angles.

YOU DO

1. Show Slide 4 and stress regular means total ÷ sides gives one angle, while irregular means sides and corners are not all equal so cannot just divide [4].
2. Model regular octagon: exterior = 360° ÷ 8 = 45° [4], then interior = 180° - 45° = 135° because interior and exterior add to 180° [4].
3. Set Slide 9 tasks: irregular pentagon last angle, regular octagon angles, polygon with exterior 24°.
4. Circulate, marking the addition then subtraction step for the irregular case.

STUDENTS DO

1. Solve the three Slide 9 problems showing triangle split or formula and division.
2. Write one number sentence showing interior + exterior = 180° [4].
3. Check answers with partner, explaining why they divided 360 and not 180.

Say: For a perfect shape you can share the total equally. Remember each exterior angle of a regular shape is 360° ÷ sides. Find the outside first, then take it from 180° to get the inside.

Worked example: Irregular pentagon total = (5 - 2) x 180° = 540° [3]. Known: 106° + 135° + 115° + 90° = 446°. Missing = 540° - 446° = 94°. Regular octagon: exterior = 360° ÷ 8 = 45° [4]; interior = 180° - 45° = 135°. Exterior 24° gives n = 360 ÷ 24 = 15 sides.

Ask: Why can we divide by 8 for a regular octagon but not for an irregular pentagon? (Regular has all corners equal so share equally [4]; irregular corners are not all equal [4].) · Exterior angles of any shape always add to what, however many sides it has? (360° [5].)

Check understanding: Mini-whiteboards show octagon exterior 45° and interior 135°, and 15 sides for 24°. Correct division error by pointing to 360° total [5].

Support: Give a worked subtraction layout with the 540° total already written at the top and allow a multiplication grid for 360 ÷ n. **Stretch:** Give an exterior angle that does not divide 360 evenly and ask them to explain what that means for a regular shape.

Use: Slides 4, 9

52–60 min **Plenary** 8 min · Whole class

Link triangle, total, and regular rules and check the objectives.

YOU DO

1. Show Slide 10 mindmap and ask pairs to retell the chain from triangle to regular ÷ n.
2. Run Slide 12 true or false: hexagon 720° with 4 x 180°, pentagon 108° with 540° ÷ 5.
3. Confirm exterior total 360° [5] and interior + exterior = 180° [4].
4. Set one-line homework and collect tables.

STUDENTS DO

1. Retell the link: triangle 180°, split into n-2 triangles, total = (n-2) x 180°.
2. Vote true or false with reasons for hexagon and pentagon statements.
3. Self-assess against I can explain why sum is (n-2) x 180°.

Say: Talk me through the whole story in one sentence each. Start with triangle 180°, then n-2 triangles, then totals, then what we do if the shape is perfect.

Ask: Why is hexagon total 4 x 180° = 720°? (Hexagon splits into 4 triangles, each 180° [3].) · Why is each regular pentagon corner 108°? (Total 540° shared by 5 equal corners, 540° ÷ 5 = 108°.)

Check understanding: Hands for true-true on both statements. If split on pentagon, re-divide 540 ÷ 5 on the board.

Support: Point to the mindmap boxes in order while students say each step aloud. **Stretch:** Ask which regular shapes could tile round a point and why 120° works for hexagons.

Use: Slides 10, 12

Common mistakes

Mistake	How to spot it	How to fix it
Using 180n instead of (n-2) x 180° for the total.	Total far too big, e.g. pentagon as 900°.	Always subtract 2 first to count triangles, then multiply by 180° [6].
Dividing the total by n for an irregular polygon.	One answer copied for all different corners.	Only divide when all corners match; otherwise add known and subtract from total [7].
Mixing interior and exterior and adding to wrong total.	Exterior found with (n-2) x 180° or interior with 360 ÷ n.	Remember they pair to 180° at each corner [6]; exteriors together make 360° [5].

Support

- Provide the shapes with one starting vertex marked and the table headings already drawn.
- Keep worked subtraction layout with totals written at top and a multiplication grid for divisions.

Stretch

- Ask them to explain in writing why the number of triangles is always two fewer than the number of sides.
- Ask for proof with division why a shape with an exterior that does not divide 360 cannot be regular.

For the LSE or teaching assistant

Sit with target pairs in main activity to guide one-vertex diagonals; prompt regular or irregular and sum or single corner in practice.

Check for understanding

Question	Answer

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Find the sum of interior angles of a heptagon.	(7-2) x 180° = 900°
Each exterior angle of a regular hexagon is what, and each interior angle is what?	Exterior 360° ÷ 6 = 60° [4]; interior 180° - 60° = 120° [4].
A regular polygon has exterior angles of 24°. How many sides?	360 ÷ 24 = 15 sides

Homework

Find one interior angle of a regular nonagon using (9-2) x 180° ÷ 9.

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