

8



Angles and shapes

Leaning Tower of Pisa stops leaning!

Sometimes, angles can cause all sorts of problems.

The building of the Leaning Tower of Pisa began in the 12th century in Pisa, Italy. The tower started tipping sideways before building had finished and, for centuries, it kept tipping further and further. It would have eventually fallen over if engineers and architects hadn't found a way to stabilise the base. In 1990, it was leaning at an angle of 5.5° from the vertical. Engineers removed soil from underneath the raised end, which straightened it a little. In 2008, even more soil was removed and now the tower leans at 3.97° . The engineers have said that it is now

stabilised and will not get any worse for more than 200 years.

Forum

What problems could be caused if a building starts to lean?

At what angle do you think the Leaning Tower of Pisa would actually fall over?

Discuss how using angles could be important for engineers fixing the Leaning Tower of Pisa.

Why learn this?

You need to get things straight about angles! They are crucial in sport—whether deciding at what angle to kick a ball, choosing the best club to use for a golf shot or trying to pocket a ball on a pool table. Construction workers need to use angles to make sure that buildings and structures are secure and will not fall down. Surveyors use distances and angles to accurately determine a position on the Earth's surface. They work in construction and establish boundary lines between properties.

After completing this chapter you will be able to:

- estimate and measure angles
- construct angles and shapes using a compass or a protractor
- classify and name angles
- calculate the size of complementary and supplementary angles, vertically opposite angles and angles in a revolution
- identify alternate, corresponding and co-interior (allied) angles and calculate their size
- define and classify polygons, especially triangles and quadrilaterals, identifying their properties.

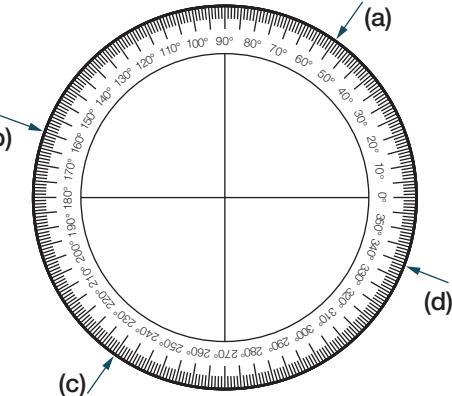
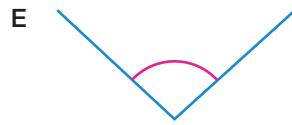
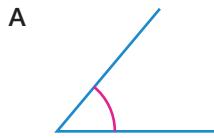
Recall 8

Prepare for this chapter by attempting the following questions. If you have difficulty with a question, go to Pearson Places and download the Recall Worksheet from Pearson Reader.

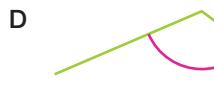
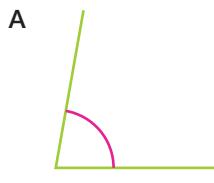


- 1 State the value indicated by each arrow in the opposite diagram.

- 2 Arrange the following angles in order from smallest to largest.



- 3 List the pairs of angles that look to be the same size.



Key Words

acute angle	equilateral triangle	plane	right angle
acute-angled triangle	intersect	plane shapes	right-angled triangle
alternate angles	irregular	polygon	scalene triangle
angle	isosceles triangle	protractor	square
arms	kite	quadrilateral	straight angle
co-interior (allied) angles	line segment	ray	supplementary angles
complementary angles	obtuse angle	rectangle	transversal
concave	obtuse-angled triangle	reflex angle	trapezium
convex	parallel lines	regular polygon	vertex
corresponding angles	perpendicular bisector	revolution	vertically opposite angles
degree	perpendicular lines	rhombus	

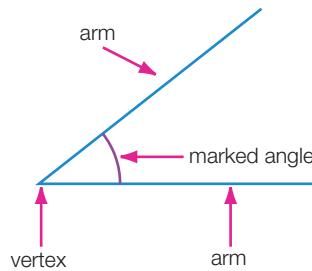
8.1

Measuring, estimating and drawing angles

An **angle** is the space between two lines that start at the same point. This point is called the **vertex** of the angle and the lines form the **arms** of the angle.

The size of an angle is the amount of turn from one arm to another. One method of measuring the amount of turn is by using **degrees** ($^\circ$). When an arm is rotated completely around a circle for one full turn, we call this a **revolution** and we divide the revolution into 360 parts.

The amount of turn through one part forms a degree.



Why was a revolution divided into 360 degrees?

It is thought that the ancient Babylonians who counted in lots of 60 and who divided a year into 360 days were responsible for dividing a revolution into 360 parts. A **protractor** has a revolution divided into 360° and is used to draw and measure angles reasonably accurately.

Full turn 360°	Half turn	Quarter turn 90°



Because two angles are formed between two arms, we need to mark the angle that is required.

Estimating and measuring angles

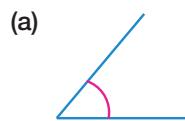
It is often important to be able to estimate angles. It may not be possible or necessary to measure the angles exactly but we need to be able to visualise how big or small an angle is. If we need to measure angles, we can use a semicircular protractor or a full-circle protractor.

Worked Example 1

WE 1

Estimate the size of each of the following angles, then use a protractor to measure the size of the angles. Write your answer, to the nearest degree, in a table using the headings as shown. Calculate the difference between your estimate and the measured size.

Estimated angle size	Measured angle size	Difference



Thinking

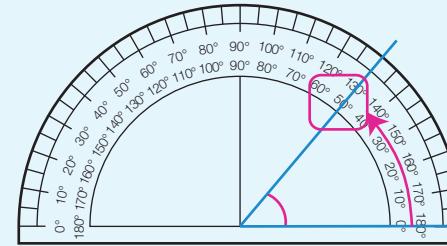
(a) For angles less than 180°

- As the angle is small and about half of a right angle (90°), estimate the size of the angle.
- Using a semicircular protractor, place the centre point of the protractor over the vertex of the angle and align the baseline of the protractor with an arm of the angle. Use the scale on the protractor that starts with 0° . This protractor measures the angle shown as 50° .
- Complete the table.



Working

(a) Estimate: 45°



Estimated angle size	Measured angle size	Difference
45°	50°	5°

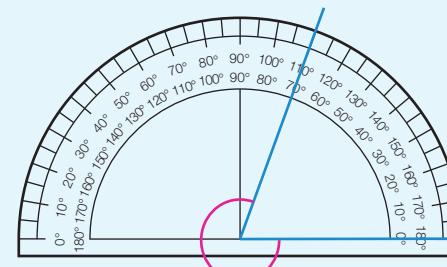
Method 1: Using a semicircular protractor

(b) For angles larger than 180°

- As the angle is greater than three right angles (270°), but less than four right angles (360°), estimate the size of the angle.
- Using a semicircular protractor, measure the smaller angle and subtract this angle from 360° .

The small angle measures 70° , so the marked angle must be $360^\circ - 70^\circ = 290^\circ$.

(b) Estimate: 300°



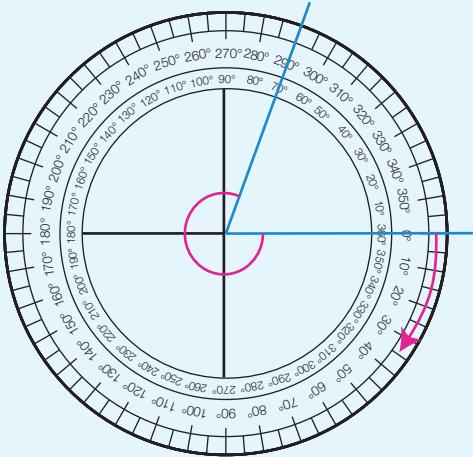
- 3 Complete the table.

Estimated angle size	Measured angle size	Difference
300°	290°	10°

Method 2: Using a full-circle protractor

- (b) 1 Using a full-circle protractor, line up the centre point with the vertex and the 0° line along one arm, as with the semicircular protractor. Use whichever scale increases from zero. In this case, the outer scale, going clockwise.

(b)



- 2 Complete the table.

Estimated angle size	Measured angle size	Difference
300°	290°	10°

Drawing angles with a protractor

Worked Example 2

WE2

Use a protractor to draw the following angles.

(a) 75° (b) 200°

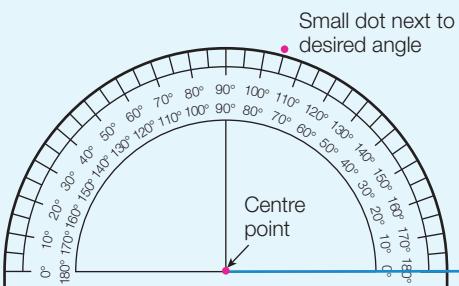
Thinking

- (a) For angles less than 180°

- 1 Draw a straight horizontal line.
- 2 Place the centre point of the baseline of the protractor on one end of the straight line. Locate the desired angle and mark a small dot as shown (in this case, 75°). (The base line is not the edge of the protractor. Make sure you use the scale starting at the end of your line segment.)
- 3 Remove the protractor and join the dot with the end of the line where the centre point was located. Mark the angle.

Working

(a)



(b) For angles larger than 180°

- Subtract the angle from 360° to get the smaller angle needed to make up a full turn. Now, draw this angle. (For example, to draw 200° , we need to first draw 160° .)

- Label the correct, larger angle.

(b)

$$360^\circ - 200^\circ = 160^\circ$$

 (160°) 200°

8.1 Measuring, estimating and drawing angles

Navigator

Answers
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Q1, Q2 Column 1, Q3, Q4, Q5,
Q6, Q7, Q9, Q10, Q11 Column
1, Q12, Q15

Q1, Q2 Column 2, Q3, Q4, Q5,
Q6, Q7, Q9, Q10, Q11 Column
2, Q12, Q13, Q16

Q1, Q2 Column 3, Q3, Q4, Q5,
Q6, Q7, Q8, Q9, Q10, Q11
Column 3, Q12, Q14, Q16

Equipment required: Protractor

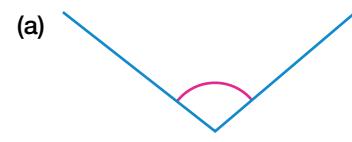
Fluency

WE1

When one arm is too short, use a ruler to make it longer first.



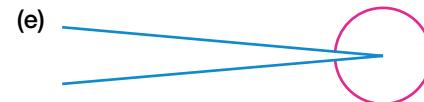
(a)



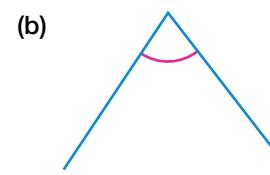
(c)



(e)



(b)



(d)



(f)



- Use a protractor to draw the following angles.

(a) 10° (b) 70° (c) 55° (d) 100° (e) 175° (f) 108° (g) 290° (h) 265° (i) 318°

WE2

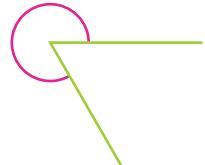
3 (a) The angle shown here is approximately:

- | | |
|---------------------|---------------------|
| A 20° | B 45° |
| C 60° | D 85° |

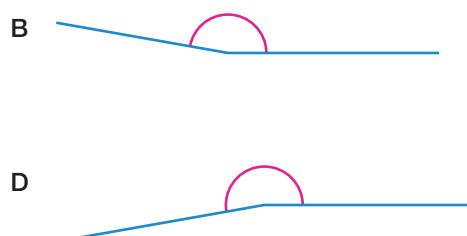
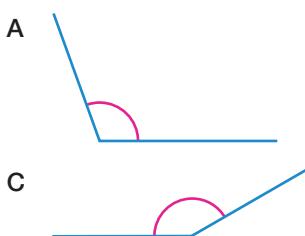


(b) The angle shown here is approximately:

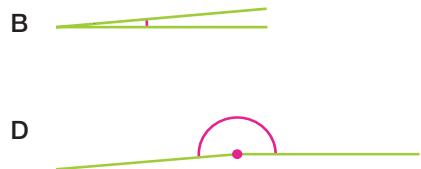
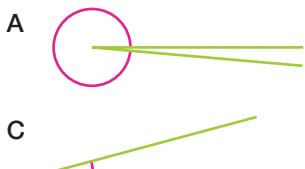
- | | |
|----------------------|----------------------|
| A 80° | B 100° |
| C 170° | D 200° |



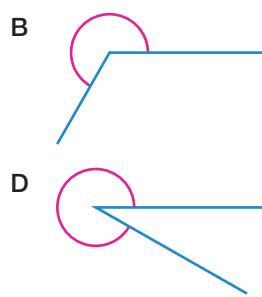
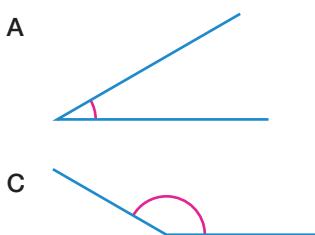
4 (a) Which of the angles below is about 170° ?



(b) Which of the angles below is about 5° ?



(c) Which of the angles below is about 330° ?

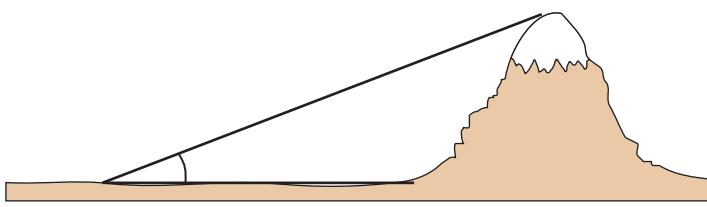


5 To draw a 250° angle with a semicircular protractor, which of the following would you do first?

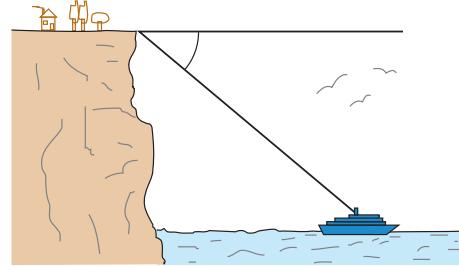
- | | |
|------------------------------------|------------------------------------|
| A Draw a 50° angle. | B Draw a 90° angle. |
| C Draw a 110° angle. | D Draw a 200° angle. |

Understanding

6 In the diagram, estimate the angle shown from ground level to the mountain top and then measure the angle with your protractor.



- 7 In the diagram, estimate the angle shown from the top of the cliff to the ship and then measure the angle with your protractor.

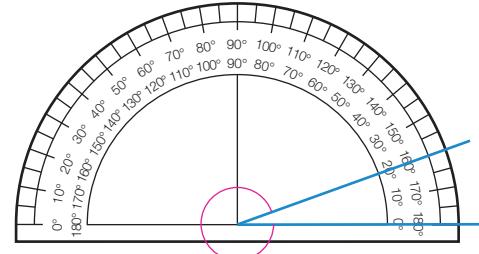


- 8 Explain how you would draw an angle of 320° with a semicircular protractor.

- 9 Liz uses a semicircular protractor to measure an angle larger than 180° .

Find the size of the actual angle (larger than 180°) if the smaller angle she has measured is:

- (a) 30° (b) 115° (c) 160°



- 10 Draw the following using your protractor.

- (a) a wire holding a vertical flagpole attached at 38° to the ground
 (b) a ramp with a slope of 12°
 (c) a ladder leaning against a vertical wall at 62° to the ground
 (d) a round birthday cake sliced into 6 equal pieces

Reasoning

- 11 For each of the following angles:

- | | | |
|-----------------|-----------------|-----------------|
| (a) 35° | (b) 65° | (c) 83° |
| (d) 120° | (e) 102° | (f) 152° |
| (g) 200° | (h) 265° | (i) 325° |

- (i) draw an estimate of the angle without the use of a protractor
 (ii) use your protractor to measure the angles you have drawn to find the actual size of your angles
 (iii) find the error (the difference between the given angle and your measurement)
 (iv) copy and complete the following table.

Estimated angle size	Measured angle size	Difference

- (v) Which angles did you draw the most accurately?
 (vi) Do you think it is harder to estimate angles greater than 180° than those less than 180° ? Why?

Open-ended

- 12 Draw the following angles, estimate the size of the angle you have drawn and then check the size with a protractor.
- (a) any angle smaller than 90°
 (b) any angle between 90° and 180°
 (c) any angle between 180° and 360°

- 13 Your friend Nick has just answered the following question.

Use a protractor to measure the size of the following angle. Give your answer to the nearest degree.



Nick says "The answers in the back of the book must be wrong! The book says that the answer is 135° , but my protractor says 45° ." Explain how Nick might have found his answer. Give Nick a hint, so that he can measure accurately all the time.

- 14 Without using a protractor, draw the following angles and estimate the size of each angle.

- (a) two angles that add up to 90°
- (b) three angles that add up to 180°
- (c) four angles that add up to 360°
- (d) Check your answers to (a), (b) and (c) with a protractor.

- 15 (a) Choose any angle between 40° and 60° , draw it carefully with a protractor and mark the size of your angle on your diagram.

- (b) Using a protractor, draw an angle 15° larger than the angle drawn in (a) and mark the size of your angle on your diagram.
- (c) Using a protractor, draw an angle 195° larger than the angle drawn in (a) and mark the size of your angle on your diagram.

- 16 (a) Choose any angle less than 90° , draw it carefully with a protractor and mark the size of your angle on your diagram.

- (b) Using a protractor, draw an angle twice the size of the angle you chose in (a) and mark the size of your angle on your diagram.
- (c) Using a protractor, draw an angle twice the size of the angle in (b) and mark the size of your angle on your diagram.

Outside the Square Game

The Angle Master

Equipment required: 2 brains, ruler, protractor

How to win:

The winner is the first player to score 15 points, and is proclaimed the 'Angle Master'.

How to play:

The aim of the game is to guess the size of different angles more accurately than your opponent.

- 1 Take it in turns to create an angle by drawing two straight lines without using a protractor. Clearly mark the angle you have created.
- 2 You and your opponent must then bid to see who can get the closer guess to the size of the angle without guessing over the size of the angle. The bidding ends when one player believes the other has overestimated the angle and calls for the angle to be measured at this guess.

Scoring

- $0-1^\circ$ under 5 points
- $2-5^\circ$ under 4 points
- $6-10^\circ$ under 2 points
- $11+^\circ$ under 1 point

Correctly claiming your opponent has overestimated the angle: 3 points.

Sample game play:

Imagine player 1 draws the following angle.



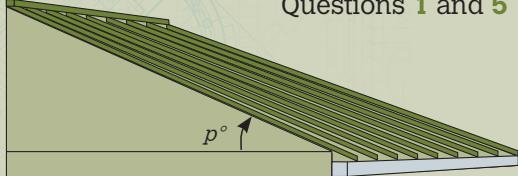
Player 2 starts the bidding at 110° , player 1 ups the bidding to 118° , player 2 ups the bidding to 124° , and player 1 calls for the angle to be measured. The angle is measured at 126° , so player 2 scores 4 points.

Constructing

The ‘pitch’ of a roof is the angle that the roof makes with the horizontal. The pitch is determined by a number of factors including visual preference, style of house, the roof ‘material’, or the weather conditions in the area in which the house is built.



Equipment required: 2 rulers and a protractor for Questions 1 and 5

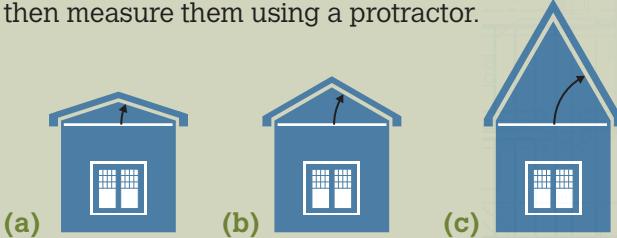


The main reason houses have a pitched roof is to redirect rainwater. A pitch of between 20° and 30° is common.

- 1 Measure the angle, p , of the pitched roof above to determine a common pitch angle for Australian house roofs.
- 2 Imagine you are building a house in an area that regularly receives a lot of heavy rain. What problems might this cause if the roof is:
 - (a) too flat? (pitch angle is too small), or
 - (b) too steep? (pitch angle is too big)

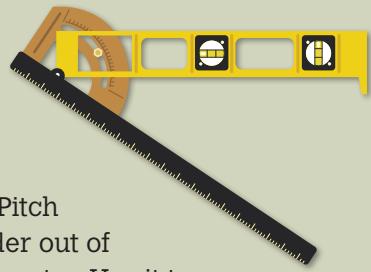
angles

- 3 Estimate the pitches of the roofs on these houses, then measure them using a protractor.



- 4 In parts of North America and Europe, where there is a lot of snow, the pitch of the roof must be at least 30° . Why do you think this is the case?

- 5 To measure an angle, builders use a *Pitch Angle and Level Finder* for construction.



Construct your own Pitch Angle and Level Finder out of two rulers and a protractor. Use it to measure the pitch of the roof of a building in your area, such as a school building or your house. You can do this by standing on the ground and holding your pitch angle and level finder in line with the roof of the building.



Research

- 6 (a) Find out some of the common pitch angles used by builders. Does there seem to be a minimum or maximum value for the pitch angle? What problems might be created if the angle is too steep?
- (b) Research the difference in pitch required by different materials, such as a thatched roof, tiled roof or corrugated iron roof.

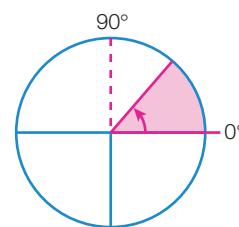


8.2

Classifying and naming angles

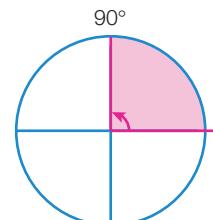
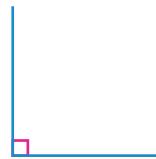
Classifying angles

Acute angle: greater than 0° but less than 90°

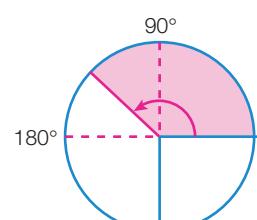


Right angle: exactly 90° , a $\frac{1}{4}$ turn.

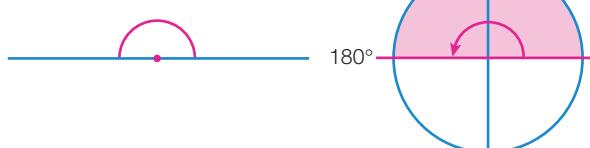
A small square drawn in the corner of an angle means it is a right angle.



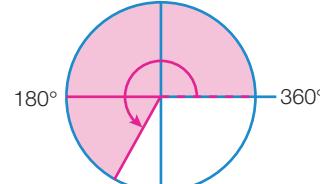
Obtuse angle: more than 90° but less than 180° .



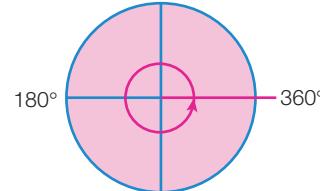
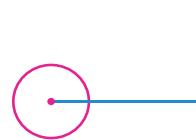
Straight angle: exactly 180° , a straight line angle, a half turn.



Reflex angle: greater than 180° but less than 360° .



Revolution: 360° , a full turn.



Points, lines and angles

A **point** defines a position in space but it has no size. It has no width or length, so a dot we can see or write is not really a point at all. We represent a point with a dot and label it with upper case letters such as A , B and P .

 P 

Similarly, a **line** we can draw or see is not really a line, because a line has no width and has no beginning or end, extending infinitely in both directions. A drawn line represents a line. A line always means a straight line and does not include curves. We can draw a line through any two points and use arrowheads on each end to show that it goes on forever in both directions.

We name a line that goes through points A and B , \overleftrightarrow{AB} .

A **ray** is part of a line. Unlike a line, a ray has a beginning. It starts at a point called the vertex and extends infinitely in one direction just like a ray of light from a torch. We draw a ray by starting it at a point and using an arrowhead on the other end.

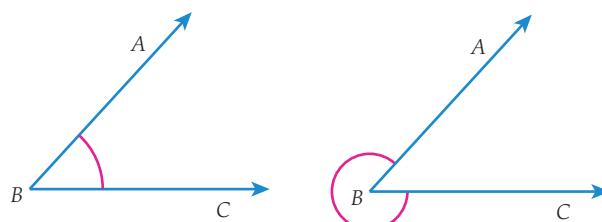


We name a ray that starts at point A and passes through B as \overrightarrow{AB} .

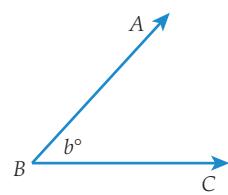
A **line segment** is part of a line that has both a beginning and an end. It can also be called an interval. We often refer to line segments as lines, but this is not strictly correct. We name a line segment that starts at A and ends at B as \overline{AB} .



If two rays have a common vertex, two angles are formed. When we draw an angle we have to mark clearly the angle we want.



You will see this notation in geometry software packages; however, we usually use line segments to draw angles. We can name the angles that are formed $\angle BAC$ and $\angle ABC$ as $\angle ABC$ or by $\angle CBA$ with the vertex B named as the middle of the three points and use the words acute, obtuse or reflex to indicate which angle we mean.



An easier and clearer way to name an angle is to use a letter with units such as a° or b° in the angle space. We usually use the same letter as the letter on the vertex.

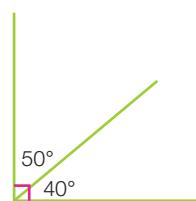
We often use Greek letters such as θ (theta) and α (alpha) to represent unknown angles.

Complementary and supplementary angles

Complementary angles add to 90° (a right angle).

40° and 50° are complementary angles because they add to 90° .

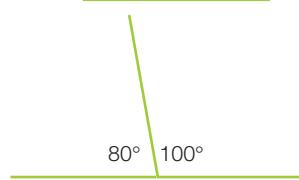
If two angles are complementary, we say one is the complement of the other. For example, 40° is the complement of 50° .



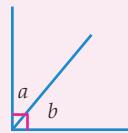
Supplementary angles add to 180° (a straight angle).

100° and 80° are supplementary angles because they add to 180° .

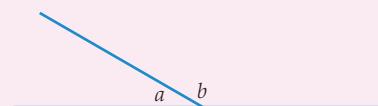
If two angles are supplementary, we say one is the supplement of the other. For example, 100° is the supplement of 80° .



Complementary angles add to 90° :
 $a + b = 90$

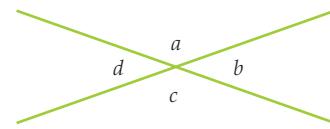


Supplementary angles add to 180° :
 $a + b = 180$



Vertically opposite angles

Whenever two lines intersect, four angles are formed. In the diagram opposite, these angles have been labelled as a , b , c and d . Pairs of angles such as a° and c° are given a special name—they are called **vertically opposite angles**.



There is another pair of vertically opposite angles in the diagram: b and d .

If you measured a and c with your protractor you would find they are the same size. The same is true for b and d . Check both of these pairs of angles for yourself.

Vertically opposite angles are equal.

8.2 Classifying and naming angles

Navigator

**Answers
page 668**

Q1 Column 1, Q2, Q3, Q4, Q5,
Q6, Q7, Q8, Q9, Q10, Q13, Q15

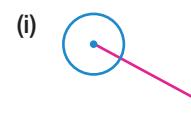
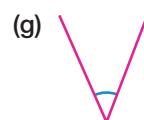
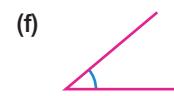
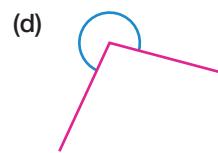
Q1 Column 2, Q2, Q3, Q4, Q5,
Q6, Q7, Q8, Q9, Q10, Q11 Q12,
Q14, Q15

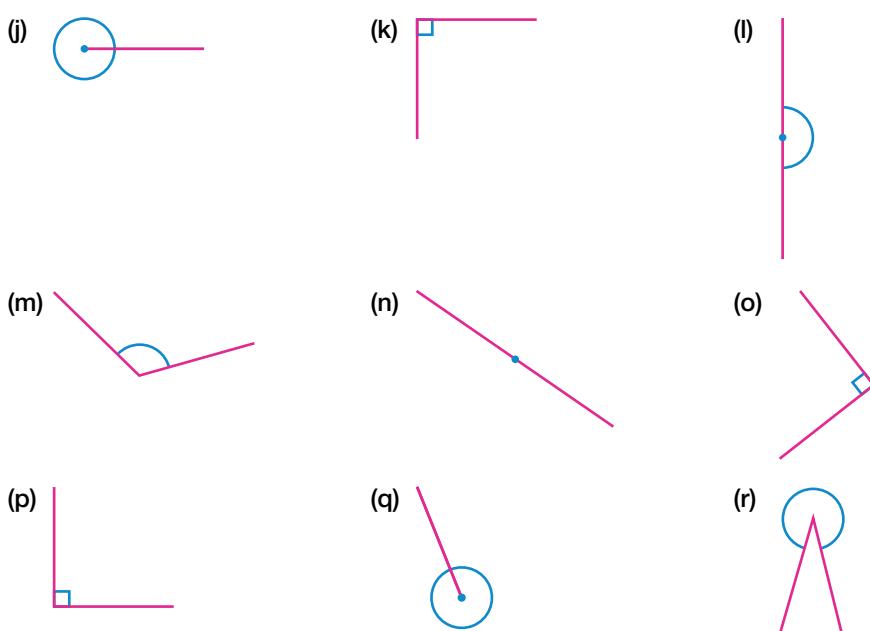
Q1 Column 3, Q2, Q3, Q4, Q5,
Q6, Q7, Q8, Q9, Q11, Q12, Q13,
Q14, Q15

Equipment required: Protractor for Questions 10(a) and 12

Fluency

- 1 State the type of angle shown in each case.

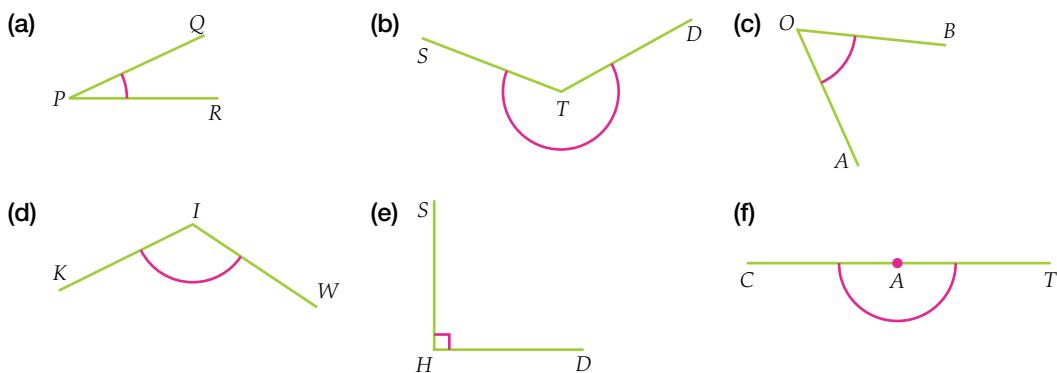




2 Classify the following angles (acute, obtuse, right etc.).

- | | | |
|-----------------|-----------------|-----------------|
| (a) 23° | (b) 117° | (c) 275° |
| (d) 360° | (e) 180° | (f) 75° |
| (g) 90° | (h) 165° | (i) 341° |

3 Name the following angles.



4 (a) Which one of the following is a pair of complementary angles?

- A 20° and 40° B 330° and 30° C 30° and 150°

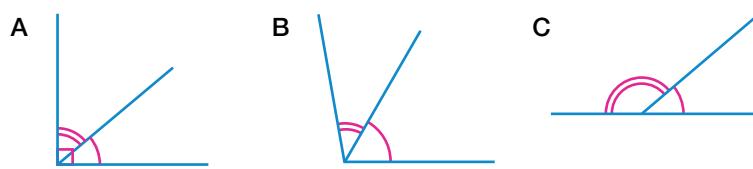
- D 15° and 75°

(b) Which one of the following is a pair of supplementary angles?

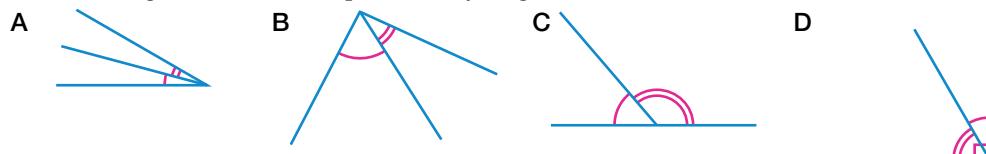
- A 0° and 90° B 45° and 55° C 90° and 90°

- D 180° and 20°

(c) Which diagram shows supplementary angles?



(d) Which diagram shows complementary angles?

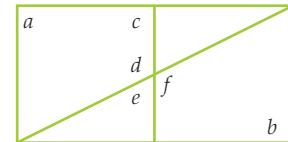


It might help you to remember that the 'c' of complementary stands for a corner (right angle) and the 's' of supplementary stands for a straight angle.



- 5 Which two angles are vertically opposite?

- A a and b
B a and c
C d and e
D d and f°



Understanding

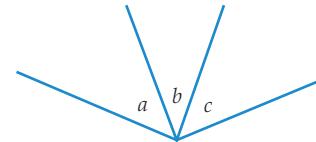
- 6 The angles a , b and c in this diagram have been drawn as adjacent angles. They have a common vertex and common arms.

For each of the following:

(a) $100^\circ, 210^\circ, 50^\circ$ (b) $32^\circ, 40^\circ, 18^\circ$

(d) $32^\circ, 161^\circ, 85^\circ, 82^\circ$ (e) $44^\circ, 46^\circ$

- (i) draw the angles as adjacent angles
(ii) find the angle sum
(iii) describe the angle you have formed.



(c) $40^\circ, 40^\circ, 100^\circ$

(f) $39^\circ, 141^\circ$

- 7 In the diagram opposite:

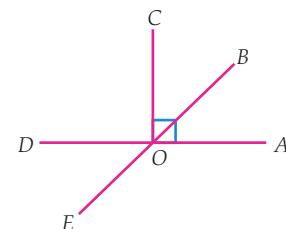
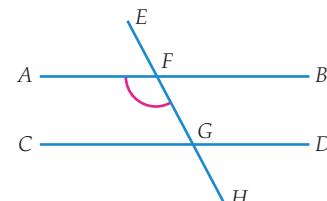
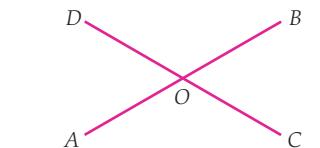
- (a) name a pair of supplementary angles
(b) name a pair of vertically opposite angles.

- 8 In the diagram, what could the marked angle be named?

- A $\angle F$
B $\angle AFE$
C $\angle AFG$
D $\angle BFG$

- 9 Using the diagram opposite, find, using letter names:

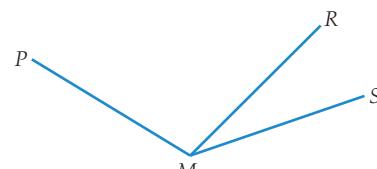
- (a) an acute angle
(b) an obtuse angle
(c) a reflex angle
(d) a right angle
(e) a straight angle
(f) one pair of complementary angles
(g) one pair of supplementary angles
(h) one pair of vertically opposite angles.



Reasoning

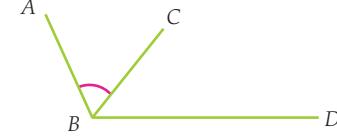
- 10 (a) Measure the reflex angle RMS in the diagram.

- (b) Why is it necessary to specify 'reflex' in part (a)?



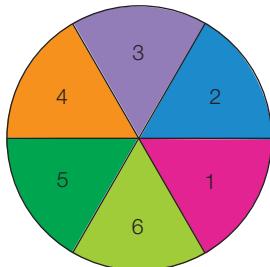
- 11 (a) Why couldn't we refer to the marked angle as $\angle B$?

- (b) Name two acute angles that have B as a vertex.
(c) Name an obtuse angle that has B as a vertex.
(d) Name a reflex angle that has B as the vertex.

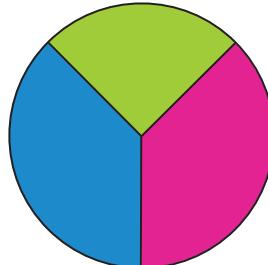


- 12** Use a protractor to draw accurate copies of the following.

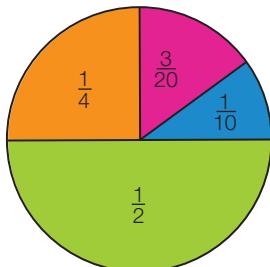
- (a) A raffle wheel divided into six equal parts.



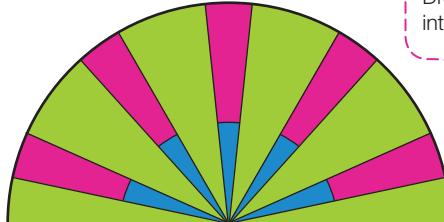
- (b) This sign.



- (c) This pie chart.



- (d) This semicircular stained glass window.



Open-ended

- 13** Draw two examples of:

- 14 (a) Write two examples of pairs of complementary angles.

- (b)** Write two examples of pairs of supplementary angles.

- 15** Write two examples of angles that add to make a revolution.

Outside the Square

Problem solving

Count the angles

Equipment required: 1 brain, 1 protractor

- 1 How many different acute angles can you count in the diagram? Measure each one.

- 2** How many different angles can you count above the horizontal line? Measure the size of each one.



- 3 How many different angles can you count in the diagram? Measure the size of each one.



Strategy options

- Test all possible combinations.
 - Break problem into manageable parts.

8.3

Calculating angles

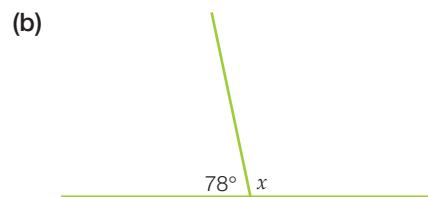
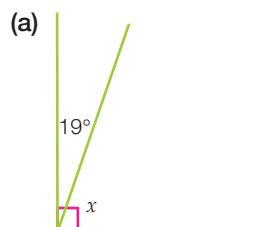
Complementary and supplementary angles

The sum of complementary angles is 90° , so we can subtract a known angle from 90° to find the unknown complementary angle. In a similar way, we can subtract a known angle from 180° to find the unknown supplementary angle.

Worked Example 3

WE3

Find the size of angle x in each diagram.



Thinking

- (a) 1 Identify the angles as complementary angles.
- 2 Write an equation with the RHS equal to 90° .
- 3 Solve the equation to find the angle.

Working

(a) x and 19° are complementary angles.
 $x + 19 = 90$
 $x + 19 - 19 = 90 - 19$
 $x = 71^\circ$

- (b) 1 Identify the angles as supplementary angles.
- 2 Write an equation with the RHS equal to 180° .
- 3 Solve the equation to find the angle.

(b) x and 78° are supplementary angles.
 $x + 78 = 180$
 $x + 78 - 78 = 180 - 78$
 $x = 102^\circ$

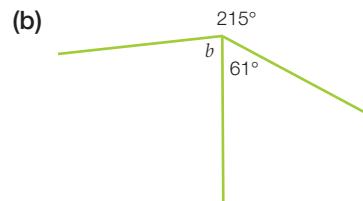
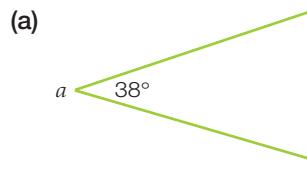
Angles in a revolution

Angles in a revolution add to 360° , so we can subtract a known angle from 360° to find the unknown angle.

Worked Example 4

WE4

Find the value of the pronumeral in each diagram.



Thinking

(a) 1 Add all the angles in the revolution, to give 360° .

2 Find the value of a .

Working

$$(a) \quad a + 38 = 360$$

$$\begin{aligned} a + 38 - 38 &= 360 - 38 \\ a &= 322^\circ \end{aligned}$$

(b) 1 Add all the angles in the revolution, to give 360° .

$$(b) \quad 215 + 61 + b = 360$$

$$276 + b = 360$$

2 Find the value of b .

$$276 - 276 + b = 360 - 276$$

$$b = 84^\circ$$

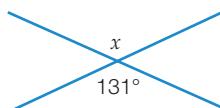
Vertically opposite angles

Vertically opposite angles are equal, so if we know one angle we know that the vertically opposite angle is the same size.

Worked Example 5

WE5

Find the value of x in the diagram.

**Thinking**

These are vertically opposite angles, which means they are equal.

Working

$$x = 131^\circ$$

8.3 Calculating angles**Navigator**

Q1 Column 1, Q2 Column 1,
Q3 Column 1, Q4, Q5, Q6, Q7
Column 1, Q8, Q10 Column 1,
Q12

Q1 Column 2, Q2 Column 2,
Q3 Column 2, Q4, Q5, Q6, Q7
Column 2, Q10 Column 2, Q11,
Q13

Q1 Column 3, Q2 Column 3,
Q3 Column 3, Q4, Q5, Q6, Q7
Column 3, Q9, Q10 Column 3,
Q11, Q12, Q13, Q14

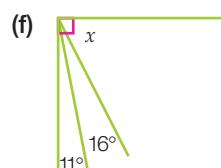
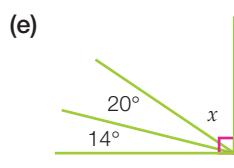
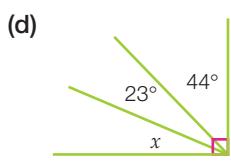
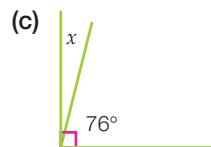
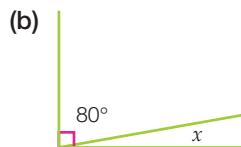
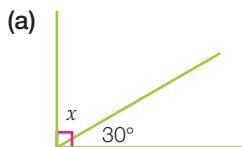
Answers
page 668

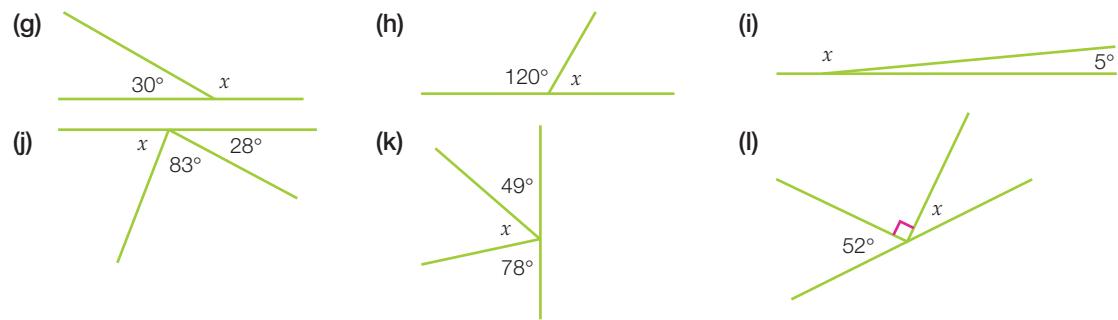
Equipment required: Protractor for Questions 11(a) and 12

Fluency

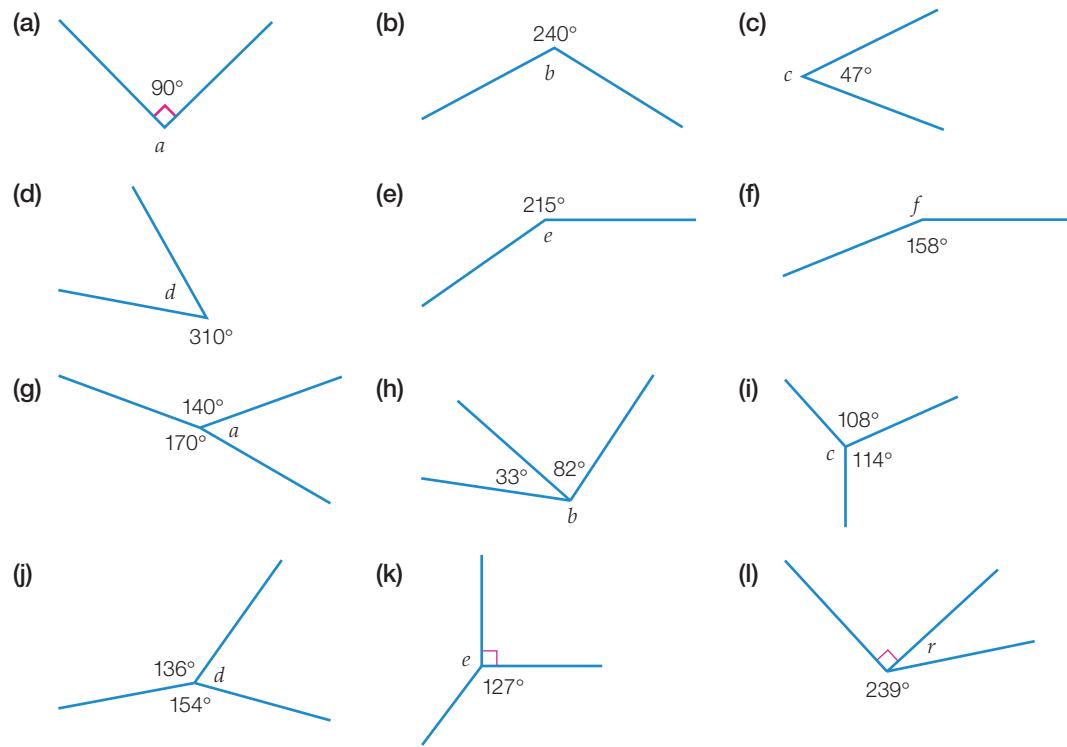
1 Find the size of angle x in each diagram.

WE3

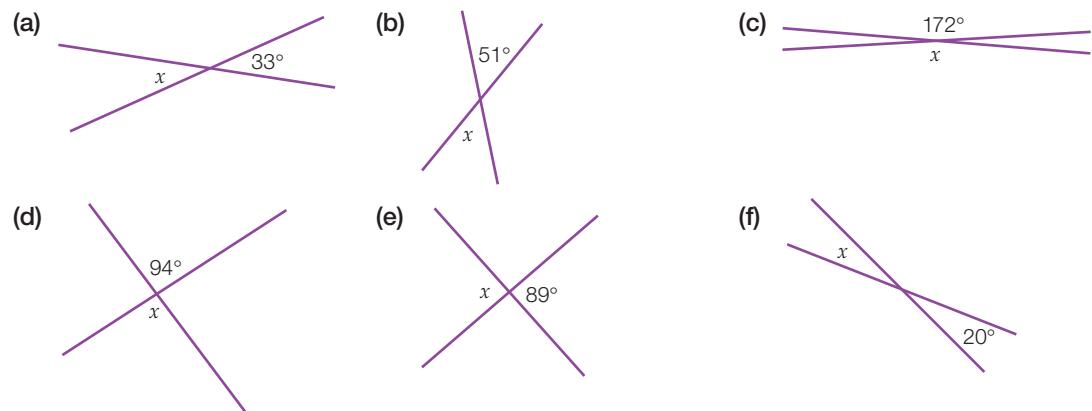




2 Find the value of the pronumeral in each diagram.



3 Find the value of x in each diagram.



The word 'complement' means to complete or make perfect!



4 Find the complement of the following angles.

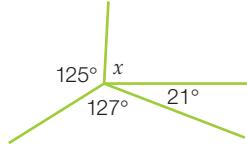
- (a) 27° (b) 45° (c) 68° (d) 15°

5 Find the supplement of the following angles.

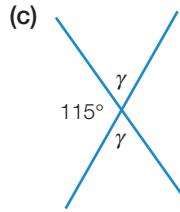
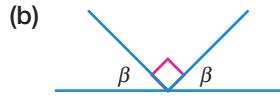
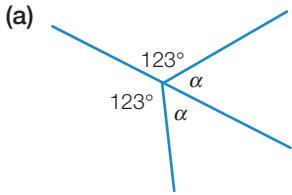
- (a) 32° (b) 90° (c) 124° (d) 176°

Understanding

- 6 Find the value of x in the diagram.

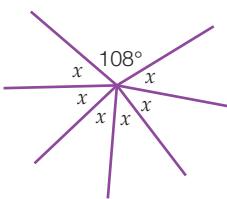


- 7 Find the value of the pronumerals in each diagram.

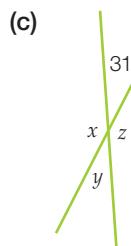
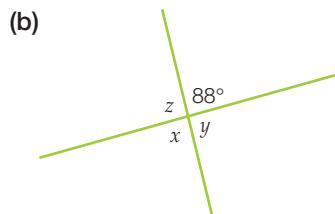
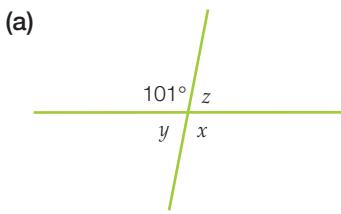


- 8 The value of x in the opposite diagram is:

- A 42° B 60°
C 108° D 360°

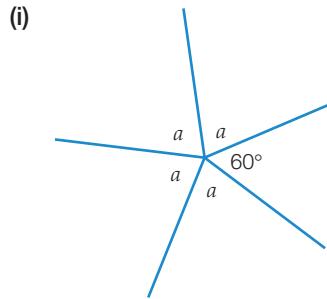
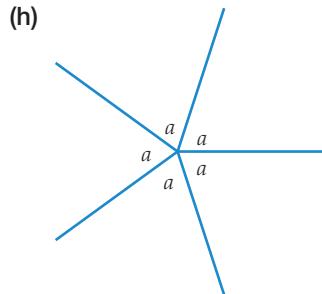
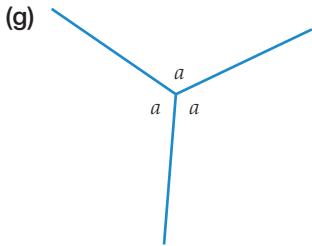
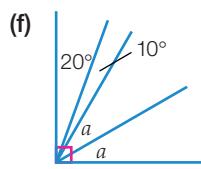
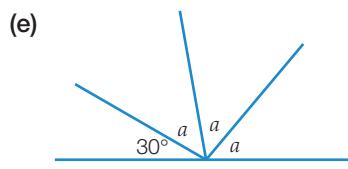
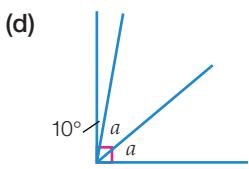
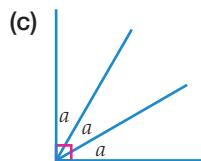
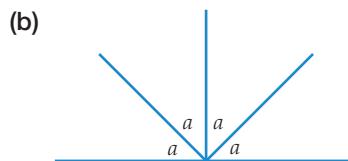
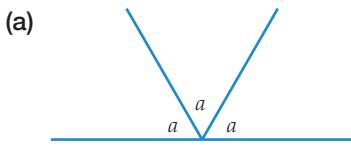


- 9 Find the value of the pronumerals in each diagram.



Reasoning

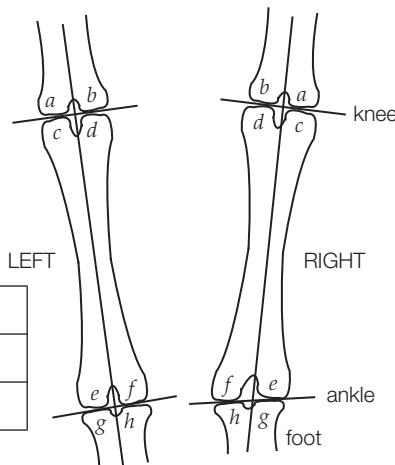
- 10 Determine the size of angle a in each diagram. Give reasons for your answer.



- 11 After breaking her leg in an accident, Kira had difficulty walking. She took her X-ray to a specialist, who marked in the following lines. He followed a procedure to decide whether she needed an operation. (You will need a protractor to measure some of the angles.)

- (a) Measure all the angles and fill in the table below.

	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>	<i>g</i>	<i>h</i>
Left leg								
Right leg								



- (b) All angles on Kira's knees must be approximately equal and all the angles on her ankles must also be approximately equal. Which leg do you think Kira broke?
(c) The differences between the angles *b* and *f*, and *c* and *g*, must be no more than 8° . If they are more, Kira needs an operation. Does she need an operation? Why?

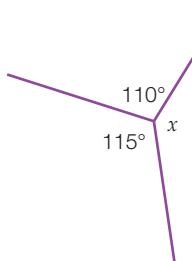
Open-ended

- 12 Sabine was answering the question on the right.

Using her protractor, Sabine measured the angle x and found that it was 140° . This was incorrect. Explain where Sabine made a mistake.

- 13 (a) Draw two lines that intersect each other.
(b) Measure the two supplementary angles you have created.
(c) Use your answers to (b) to work out the two angles you did not measure.

Find the value of the pronumeral.



- 14 Draw two straight lines that intersect, forming two acute angles. What are the sizes of the other two angles?

Outside the Square Problem solving

Ella's angles

Ella needs to draw a 60° angle, but she has lost her protractor. She has a stencil that can draw 90° and 40° angles. How can she use these two angle sizes to draw a 60° angle?



Strategy options

- Draw a diagram.
- Guess and check.

