


Explore It!

The intersecting skis form four angles.



Lesson 10-4
Solve Problems Using Angle Relationships

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I can...
solve problems involving angle relationships.

A. List all the pairs of angles that share a ray.

B. Suppose the measure of $\angle 1$ increases. What happens to the size of $\angle 2$? $\angle 3$?

C. How does the sum of the measures of $\angle 1$ and $\angle 2$ change when one ski moves? Explain.

Focus on math practices

Construct Arguments Why does the sum of all four angle measures stay the same when one of the skis moves?

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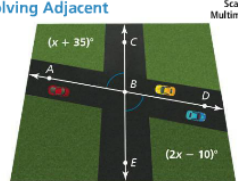
Essential Question How are angles formed by intersecting lines related?

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EXAMPLE 1 Solve Problems Involving Adjacent and Vertical Angles

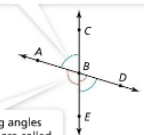
A skewed intersection has two roads that intersect at more than 20 degrees away from 90° . Determine whether the road intersection shown is skewed by finding the measures of $\angle ABC$ and $\angle DBE$.



Look for Relationships What angle measures would a skewed intersection have?

Examine how the angles are related.

Angles opposite each other are called **vertical angles**. Vertical angles have equal measures. $\angle ABC$ and $\angle DBE$ are vertical angles.



Non-overlapping angles that share a ray are called **adjacent angles**. $\angle ABE$ and $\angle EBD$ are adjacent angles, sharing ray BE .

Write and solve an equation to find the value of x .

Read "m" as "the measure of" the named angle.

$$m\angle ABC = m\angle DBE$$

$$x + 35 = 2x - 10$$

$$x + 35 + 10 = 2x - 10 + 10$$

$$x + 45 = 2x$$

$$x - x + 45 = 2x - x$$

$$45 = x$$

Find the measure of an angle in the intersection.

$$m\angle ABC = (x + 35)^\circ$$

$$= (45 + 35)^\circ$$

$$= 80^\circ$$

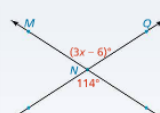
$\angle ABC$ and $\angle DBE$ both measure 80° .

Since 80° is within 20° of 90° , the road intersection is not skewed.

Try It!

$\angle MNO$ and $\angle PNR$ are vertical angles. What is the value of x ?

Vertical angles are , so the equation can be used to find x . The value of x is .



Convince Me! Why can you use an equation when solving for x in the diagram?

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EXAMPLE 2 Solve Problems Involving Complementary and Supplementary Angles

a. Ray EG splits right angle DEF into two angles, $\angle DEG$ and $\angle GEF$. Find the value of x .

b. The two angles shown are supplementary angles. Find the value of x .

Complementary angles have a sum of 90°

$m\angle DEG + m\angle GEF = 90$
 $3x + 36 = 90$
 $3x + 36 - 36 = 90 - 36$
 $3x = 54$
 $\frac{3x}{3} = \frac{54}{3}$
 $x = 18$

Supplementary angles have a sum of 180°

$(\frac{x}{2} - 4) + 50 = 180$
 $\frac{x}{2} + 46 = 180$
 $\frac{x}{2} + 46 - 46 = 180 - 46$
 $\frac{x}{2} = 134$
 $2 \cdot \frac{x}{2} = 2 \cdot 134$
 $x = 268$

straight = 180°

EXAMPLE 3 Find the Measure of an Unknown Angle

Find the measure of $\angle PAR$.

STEP 1 Use vertical angles to find the value of x .

$m\angle UAG = m\angle KAR$
 $6x = 2x + 16$
 $6x - 2x = 2x - 2x + 16$
 $4x = 16$
 $\frac{4x}{4} = \frac{16}{4}$
 $x = 4$

$m\angle UAG = (6x)^\circ = (6 \cdot 4)^\circ = 24^\circ$
 So $m\angle KAR = 24^\circ$.

STEP 2 Use complementary angles to find the measure of $\angle PAR$.

$m\angle KAR + m\angle PAR = 90^\circ$
 $24^\circ + m\angle PAR = 90^\circ$
 $m\angle PAR = 66^\circ$

Try It!

$m\angle 1$ is 4 times $m\angle 2$. $\angle 1$ and $\angle 2$ are complementary. $\angle 1$ and $\angle 3$ are vertical angles. $\angle 3$ and $\angle 4$ are supplementary. What are the measures of the four angles?

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KEY CONCEPT

This ray is shared by Angles 1 and 2, so they are **adjacent**.

Angles 4 and 5 form a straight line and add up to 180° , so they are **supplementary**.

The sum of Angles 2 and 3 is 90° , so they are **complementary**.

Angles 1 and 4 are opposite each other, so they are **vertical**.

2 smaller angles that form a straight line

opposite angles → congruent

Do You Understand?

- Essential Question** How are angles formed by intersecting lines related?
- Use Structure** Can vertical angles also be adjacent angles? Explain.
- Reasoning** Do complementary and supplementary angles also have to be adjacent angles? Explain.

Do You Know How?

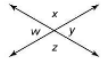
Use the diagram below for 4-6.

- List two pairs of adjacent angles.
 $\angle 4$ and $\angle 5$ $\angle 1$ and $\angle 5$
- List all pairs of vertical angles.
 $\angle 1$ and $\angle 3$
- If $\angle 1$ and $\angle 3$ are the same measure, what is the value of x ?
 $9x = 90$
 $x = 10$

Name: _____

Practice & Problem Solving

7. List each angle adjacent to $\angle w$.



8. List two pairs of adjacent angles.



9. Find the value of x .

Handwritten solution for problem 9:

$$9x + 90 + 18 = 180$$

$$9x + 108 = 180$$

$$-108 = -108$$

$$9x = 72$$

$$\frac{9x}{9} = \frac{72}{9}$$

$$x = 8$$

10. Find the value of x .

Handwritten solution for problem 10:

vertical (opposite)
congruent

$$125 = 5x + 30$$

$$-30 = -30$$

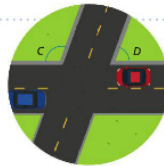
$$95 = 5x$$

$$\frac{95}{5} = \frac{5x}{5}$$

$$19 = x$$

$$x = 19$$

12. Two streets form an intersection. $\angle C$ and $\angle D$ are supplementary angles. If the measure of $\angle C$ is 128° and the measure of $\angle D$ is two times the value of x , what is the value of x ?



13. If $\angle A$ and $\angle B$ are supplementary angles and $\angle A$ is three times as large as $\angle B$, find the measures of $\angle A$ and $\angle B$.

14. Higher Order Thinking The measure of $\angle DBE$ is $(0.1x - 22)^\circ$ and the measure of $\angle CBE$ is $(0.3x - 54)^\circ$. Find the value of x .

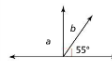


15. Reasoning $\angle 1$ and an angle that measures 50° are supplementary. Another angle that measures 50° and $\angle 3$ are supplementary. Show that $m\angle 1$ and $m\angle 3$ are equal.

Assessment Practice

16. Using the diagram at the right, Martin incorrectly writes $m\angle b = 125^\circ$.

PART A
Find the correct measure of $\angle b$.



PART B
What mistake did he likely make?

- Ⓐ He subtracted 55° from 90° instead of 180° .
- Ⓑ He subtracted 55° from 180° instead of 90° .
- Ⓒ He added 55° to 180° instead of 90° .
- Ⓓ He added 55° to 90° instead of 180° .

17. In the diagram at the right, $m\angle 1 = (133 - y)^\circ$, $m\angle 2 = 22^\circ$, and $m\angle 3 = (x + 48)^\circ$. Find the values of x and y .

Handwritten solution for problem 17:

$$(90 + 22) + x + 48 = 180$$

$$133 + x + 48 = 180$$

$$x + 181 = 180$$

$$-181 = -181$$

$$x = -1$$

$$133 + y = 90$$

$$-133 = -133$$

$$y = -43$$

