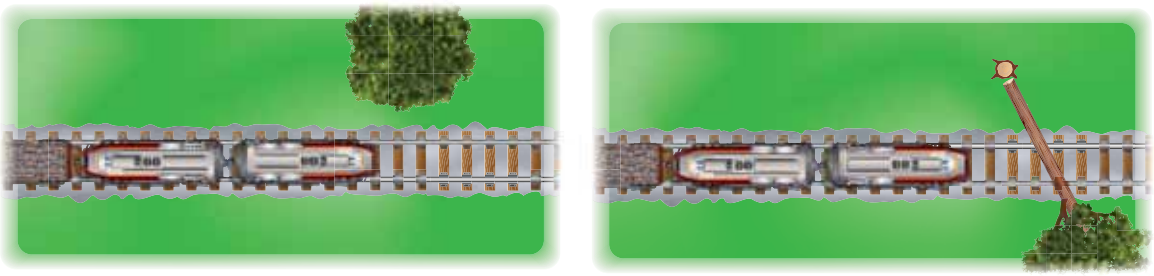
3.1 Parallel Lines and Transversals

Essential Question How can you describe angles formed by parallel lines and transversals?

The Meaning of a Word ● Transverse

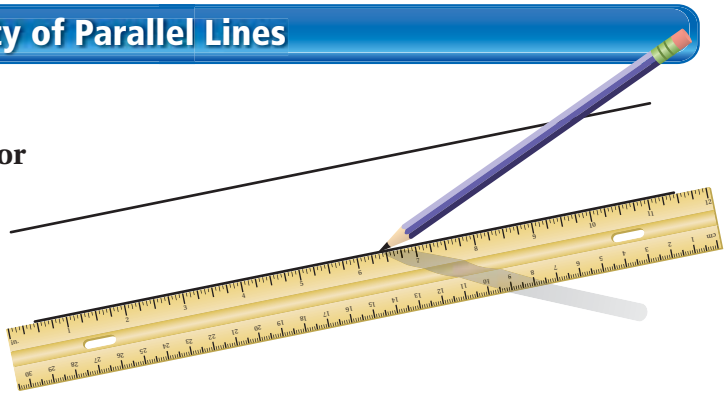
When an object is **transverse**, it is lying or extending across something.

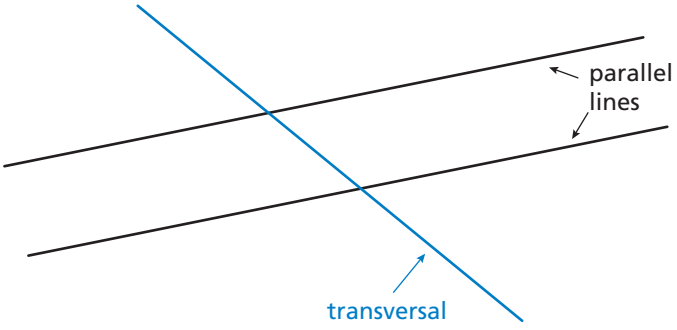


1 ACTIVITY: A Property of Parallel Lines

Work with a partner.

- **Discuss what it means for two lines to be parallel. Decide on a strategy for drawing two parallel lines. Then draw the two parallel lines.**
- **Draw a third line that intersects the two parallel lines. This line is called a transversal.**





a. How many angles are formed by the parallel lines and the transversal? Label the angles.

b. Which of these angles have equal measures? Explain your reasoning.

Common Core

Geometry

In this lesson, you will

- identify the angles formed when parallel lines are cut by a transversal.
- find the measures of angles formed when parallel lines are cut by a transversal.

Learning Standard 8.G.5

2 ACTIVITY: Creating Parallel Lines

Math Practice 6

Use Clear Definitions

What do the words *parallel* and *transversal* mean? How does this help you answer the question in part (a)?

Work with a partner.

a. If you were building the house in the photograph, how could you make sure that the studs are parallel to each other?

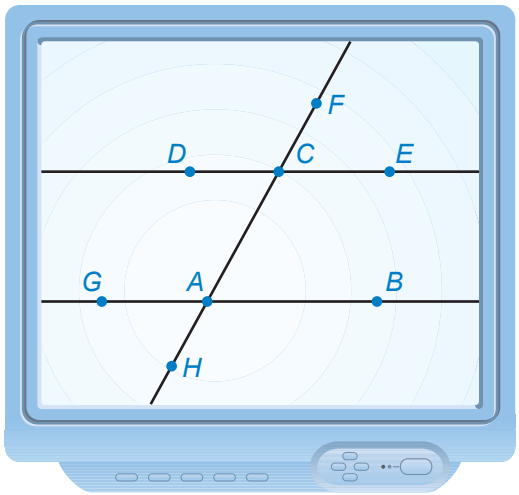
b. Identify sets of parallel lines and transversals in the photograph.

3 ACTIVITY: Using Technology

Work with a partner. Use geometry software to draw two parallel lines intersected by a transversal.

a. Find all the angle measures.

b. Adjust the figure by moving the parallel lines or the transversal to a different position. Describe how the angle measures and relationships change.



What Is Your Answer?

4. **IN YOUR OWN WORDS** How can you describe angles formed by parallel lines and transversals? Give an example.

5. Use geometry software to draw a transversal that is perpendicular to two parallel lines. What do you notice about the angles formed by the parallel lines and the transversal?

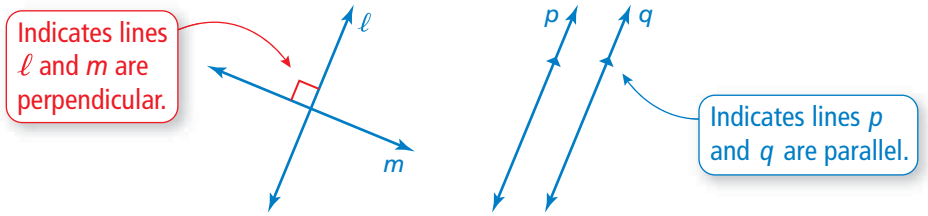
Practice Use what you learned about parallel lines and transversals to complete Exercises 3–6 on page 107.

3.1 Lesson

Check It Out
Lesson Tutorials
BigIdeasMath.com

Key Vocabulary
transversal, *p. 104*
interior angles, *p. 105*
exterior angles, *p. 105*

Lines in the same plane that do not intersect are called *parallel lines*. Lines that intersect at right angles are called *perpendicular lines*.

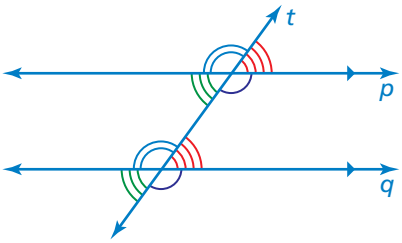


A line that intersects two or more lines is called a **transversal**. When parallel lines are cut by a transversal, several pairs of congruent angles are formed.

Key Idea

Corresponding Angles

When a transversal intersects parallel lines, corresponding angles are congruent.

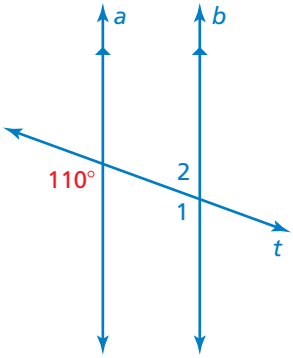


Corresponding angles

Study Tip

Corresponding angles lie on the same side of the transversal in corresponding positions.

EXAMPLE 1 Finding Angle Measures



Use the figure to find the measures of (a) ∠1 and (b) ∠2.

a. ∠1 and the 110° angle are corresponding angles. They are congruent.

∴ So, the measure of ∠1 is 110°.

b. ∠1 and ∠2 are supplementary.

$\angle 1 + \angle 2 = 180°$ Definition of supplementary angles

$110° + \angle 2 = 180°$ Substitute 110° for ∠1.

$\angle 2 = 70°$ Subtract 110° from each side.

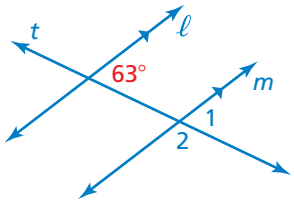
∴ So, the measure of ∠2 is 70°.

On Your Own

Now You're Ready
Exercises 7–9

Use the figure to find the measure of the angle. Explain your reasoning.

1. ∠1 **2.** ∠2



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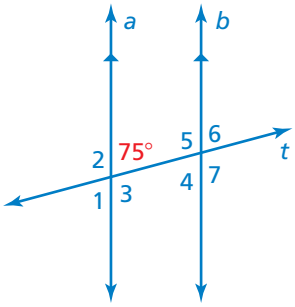
EXAMPLE 2 Using Corresponding Angles



Use the figure to find the measures of the numbered angles.

$\angle 1$: $\angle 1$ and the 75° angle are vertical angles. They are congruent.

∴ So, the measure of $\angle 1$ is 75°.

$\angle 2$ and $\angle 3$: The 75° angle is supplementary to both $\angle 2$ and $\angle 3$.

$75° + \angle 2 = 180°$ Definition of supplementary angles

$\angle 2 = 105°$ Subtract 75° from each side.

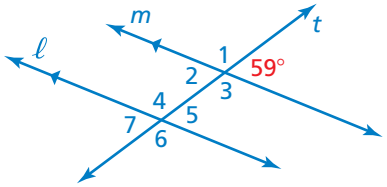
∴ So, the measures of $\angle 2$ and $\angle 3$ are 105°.

$\angle 4$, $\angle 5$, $\angle 6$, and $\angle 7$: Using corresponding angles, the measures of $\angle 4$ and $\angle 6$ are 75°, and the measures of $\angle 5$ and $\angle 7$ are 105°.

On Your Own

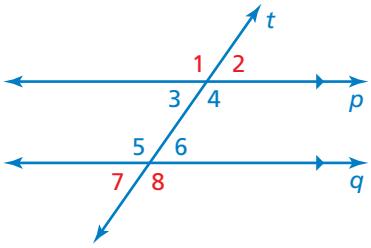
Now You're Ready
Exercises 15–17

3. Use the figure to find the measures of the numbered angles.



When two parallel lines are cut by a transversal, four **interior angles** are formed on the inside of the parallel lines and four **exterior angles** are formed on the outside of the parallel lines.

$\angle 3$, $\angle 4$, $\angle 5$, and $\angle 6$ are interior angles.
$\angle 1$, $\angle 2$, $\angle 7$, and $\angle 8$ are exterior angles.



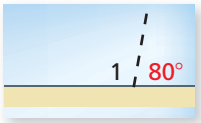
EXAMPLE 3 Using Corresponding Angles

A store owner uses pieces of tape to paint a window advertisement. The letters are slanted at an 80° angle. What is the measure of $\angle 1$?

Ⓐ 80° Ⓑ 100° Ⓒ 110° Ⓓ 120°

Because all the letters are slanted at an 80° angle, the dashed lines are parallel. The piece of tape is the transversal.

Using corresponding angles, the 80° angle is congruent to the angle that is supplementary to $\angle 1$, as shown.



∴ The measure of $\angle 1$ is $180° - 80° = 100°$. The correct answer is Ⓑ.

On Your Own

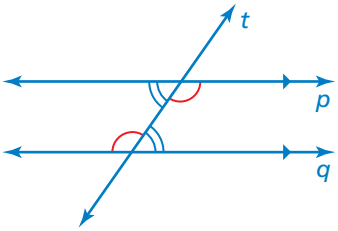
Now You're Ready
Exercises 18 and 19

4. WHAT IF? In Example 3, the letters are slanted at a 65° angle. What is the measure of ∠1?

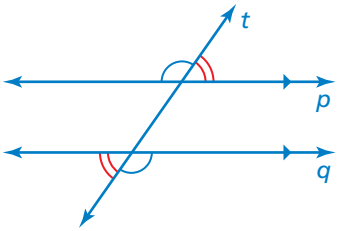
Key Idea

Alternate Interior Angles and Alternate Exterior Angles

When a transversal intersects parallel lines, alternate interior angles are congruent and alternate exterior angles are congruent.



Alternate interior angles



Alternate exterior angles

Study Tip

Alternate interior angles and alternate exterior angles lie on opposite sides of the transversal.

EXAMPLE 4 Identifying Alternate Interior and Alternate Exterior Angles

The photo shows a portion of an airport. Describe the relationship between each pair of angles.

a. ∠3 and ∠6

∠3 and ∠6 are alternate exterior angles.

∴ So, ∠3 is congruent to ∠6.

b. ∠2 and ∠7

∠2 and ∠7 are alternate interior angles.

∴ So, ∠2 is congruent to ∠7.

On Your Own

Now You're Ready
Exercises 20 and 21

In Example 4, the measure of ∠4 is 84°. Find the measure of the angle. Explain your reasoning.

5. ∠3 **6.** ∠5 **7.** ∠6

3.1 Exercises

Check It Out
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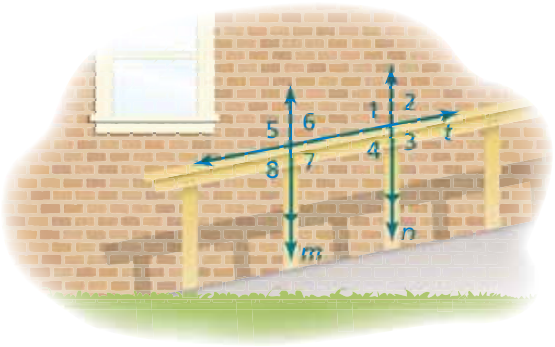
Vocabulary and Concept Check

1. **VOCABULARY** Draw two parallel lines and a transversal. Label a pair of corresponding angles.

2. **WHICH ONE DOESN'T BELONG?** Which statement does *not* belong with the other three? Explain your reasoning. Refer to the figure for Exercises 3–6.

The measure of $\angle 2$	The measure of $\angle 5$
The measure of $\angle 6$	The measure of $\angle 8$

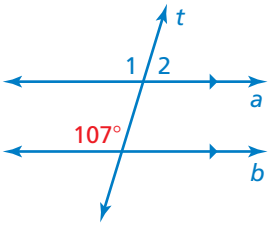
Practice and Problem Solving

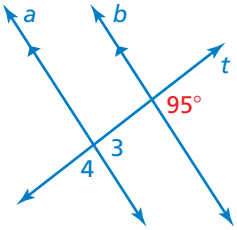


In Exercises 3–6, use the figure.

3. Identify the parallel lines.
4. Identify the transversal.
5. How many angles are formed by the transversal?
6. Which of the angles are congruent?

Use the figure to find the measures of the numbered angles.

7.


8.


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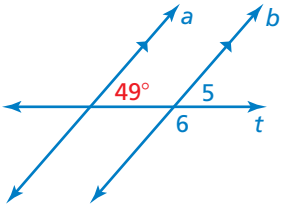
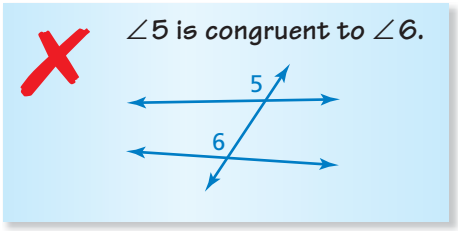


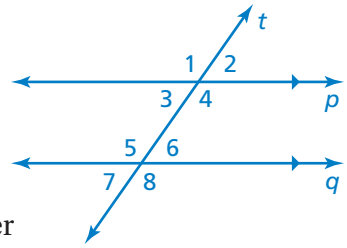
10. **ERROR ANALYSIS** Describe and correct the error in describing the relationship between the angles.



11. **PARKING** The painted lines that separate parking spaces are parallel. The measure of $\angle 1$ is 60°. What is the measure of $\angle 2$? Explain.

12. **OPEN-ENDED** Describe two real-life situations that use parallel lines.

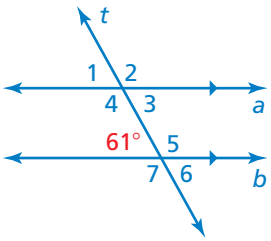
13. **PROJECT** Trace line p and line t on a piece of paper. Label $\angle 1$. Move the paper so that $\angle 1$ aligns with $\angle 8$. Describe the transformations that you used to show that $\angle 1$ is congruent to $\angle 8$.



14. **REASONING** Two horizontal lines are cut by a transversal. What is the least number of angle measures you need to know in order to find the measure of every angle? Explain your reasoning.

Use the figure to find the measures of the numbered angles. Explain your reasoning.

15.



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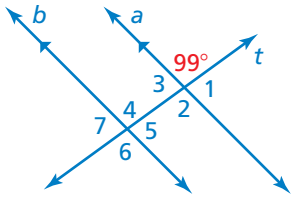

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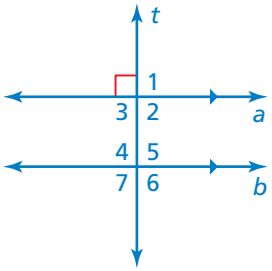
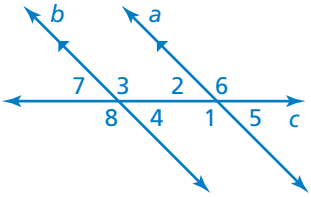


Complete the statement. Explain your reasoning.

18. If the measure of $\angle 1 = 124°$, then the measure of $\angle 4 =$ ____.

19. If the measure of $\angle 2 = 48°$, then the measure of $\angle 3 =$ ____.

20. If the measure of $\angle 4 = 55°$, then the measure of $\angle 2 =$ ____.

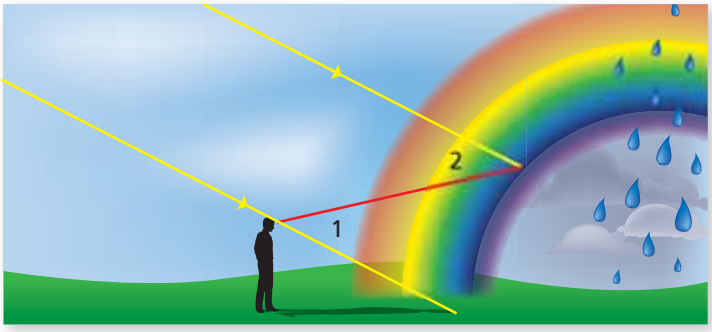


21. If the measure of $\angle 6 = 120°$, then the measure of $\angle 8 =$ ____.

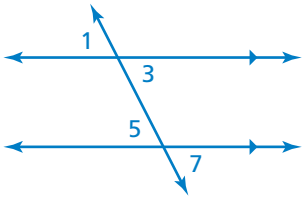
22. If the measure of $\angle 7 = 50.5°$, then the measure of $\angle 6 =$ ____.

23. If the measure of $\angle 3 = 118.7°$, then the measure of $\angle 2 =$ ____.

24. **RAINBOW** A rainbow forms when sunlight reflects off raindrops at different angles. For blue light, the measure of $\angle 2$ is 40°. What is the measure of $\angle 1$?



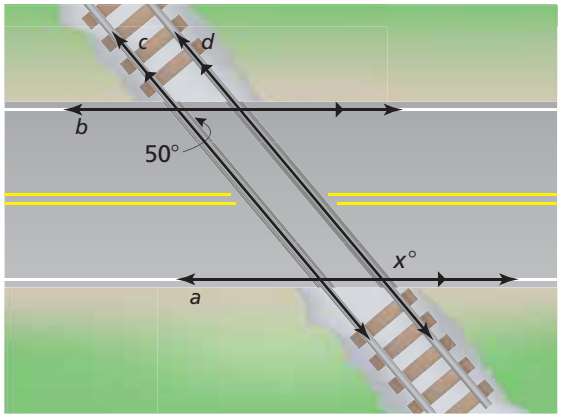
25. **REASONING** When a transversal is perpendicular to two parallel lines, all the angles formed measure 90°. Explain why.



26. **LOGIC** Describe two ways you can show that $\angle 1$ is congruent to $\angle 7$.

CRITICAL THINKING **Find the value of x.**

27.



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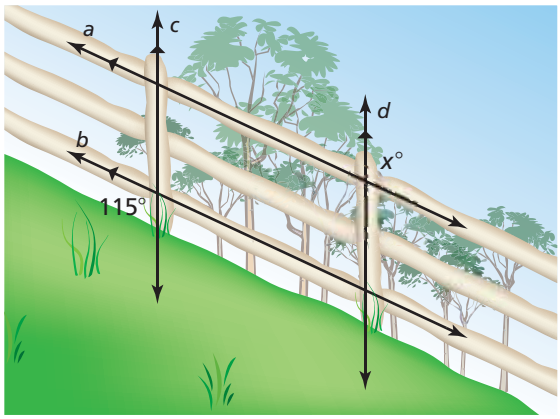
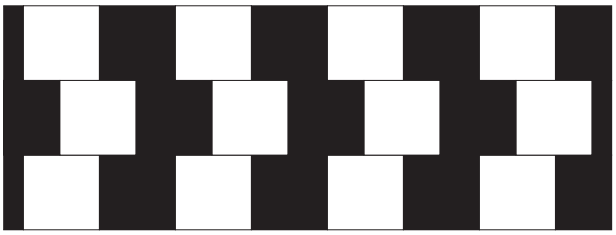
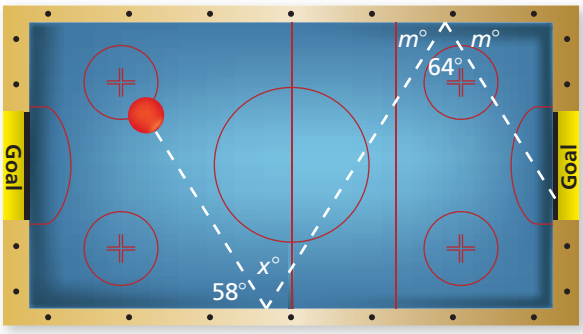


29. **OPTICAL ILLUSION** Refer to the figure.

a. Do the horizontal lines appear to be parallel? Explain.

b. Draw your own optical illusion using parallel lines.





30. Geometry The figure shows the angles used to make a double bank shot in an air hockey game.

a. Find the value of x.

b. Can you still get the red puck in the goal when x is increased by a little? by a lot? Explain.

Fair Game Review What you learned in previous grades & lessons

Evaluate the expression. *(Skills Review Handbook)*

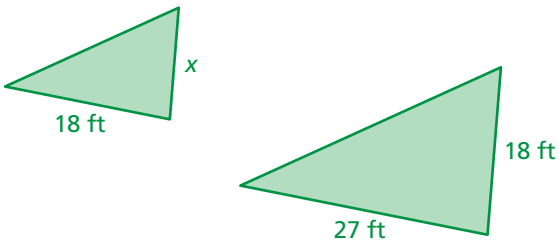
31. $4 + 3^2$

32. $5(2)^2 - 6$

33. $11 + (-7)^2 - 9$

34. $8 \div 2^2 + 1$

35. **MULTIPLE CHOICE** The triangles are similar. What length does x represent? *(Section 2.5)*



(A) 2 ft (B) 12 ft

(C) 15 ft (D) 27 ft