LESSON 2-1
Parallel Lines

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Program Resources

Lesson Overview

KEY CONCEPTS

Mathematics Objectives
- ✔ Define parallel lines using the undefined terms *point* and *line*.
- ✔ Prove theorems about lines and angles and use them to find the measures of angles formed by parallel lines and a transversal.

Language Objective
- ✔ Use correct terms for angles formed by parallel lines and a transversal.

Essential Understanding
When parallel lines are cut by a transversal, the special angle pairs that are formed are congruent, supplementary, or both.

COHERENCE

Previously in this course, students:
- Studied special angle pairs, including adjacent, supplementary, and vertical angles and linear pairs.

In this lesson, students:
- Define angle pairs formed by parallel lines and a transversal and prove theorems about them.
- Use the Same-Side Interior Angles Postulate and the Alternate Interior Angles, Corresponding Angles, and Alternate Exterior Angles Theorems to find the measures of angles formed by parallel lines and a transversal.

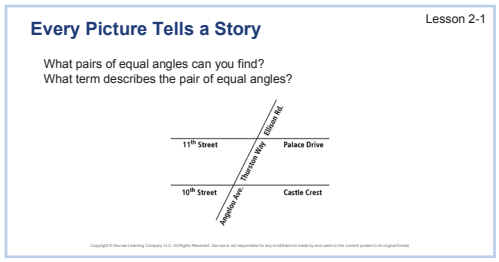
Later in this topic, students will:
- Use congruent and supplementary special angle pairs to prove lines parallel.

BALANCE

This lesson emphasizes a blend of *conceptual understanding* and *procedural skill and fluency*.
- Students use deductive reasoning with stated postulates, definitions, and proven theorems to prove theorems about special angle pairs associated with parallel lines.
- Students use postulates and theorems to find the measures of special angle pairs associated with parallel lines.

Presentation is available at SavvasRealize.com.

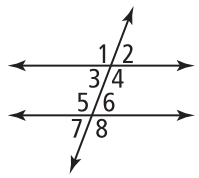
Math Talk
For use before this lesson.



TEKS G.5A

Every Picture Tells a Story Present the illustration, providing time for students to look it over and see how the streets are named. Ask students to identify an intersection that appears to make a pair of equivalent angles. Then ask for volunteers to share the intersection and angles they identified. Show the simplified image below.

Have students sort the numbered angles into larger angles and smaller angles.



Skills Review & Practice
Present or assign to reactivate prior knowledge.
- **G12** Properties of Parallel Lines

Vocabulary Builder
Use the Vocabulary Builder activity online to support understanding of the terms *alternate exterior angles*, *alternate interior angles*, *corresponding angles*, *parallel*, and *transversal*.

Texas Essential Knowledge and Skills (TEKS)
Linear functions, equations, and inequalities. The student applies the mathematical process standards to solve, with and without technology, linear equations and evaluate the reasonableness of their solutions. The student is expected to:

G.5A solve linear equations in one variable, including those for which the application of the distributive property is necessary and for which variables are included on both sides. Also **G.6A**

Mathematical Process Standards
The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to:

G.1B use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution.

English Language Proficiency Standards (ELPS)
SPEAKING 2B Speak using content-area vocabulary during formal and informal classroom interactions to demonstrate acquisition of new words and high-frequency words.

College and Career Readiness Standards
II.C.3 Recognize and use algebraic properties, concepts, and algorithms to solve equations, inequalities, and systems of linear equations and inequalities. Also **III.C.1** and **III.D.3**

Standards in **VII** Problem Solving and Reasoning, **VIII** Communication and Representation, and **IX** Connections are infused throughout the program.

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Activity

EXPLORE & SHARE

INSTRUCTIONAL FOCUS Students become familiar with the angles formed by parallel lines and a transversal and look for relationships between these angles.

STUDENT COMPANION Students can do their work for the task on their *Student Companion* pages, which you can print from **SavvasRealize.com**.

Before WHOLE CLASS

Implement Tasks that Promote Reasoning and Problem Solving

Q: What are parallel lines? [coplanar lines that do not intersect]

Q: The parallel lines are "cut by a transversal." What do you think is meant by the term "cut"? What do you think a transversal is? [Sample: intersected by; a line that intersects two parallel lines]

Q: Can you think of a real-world situation that involves parallel lines and a transversal? [Sample: Two sides of a street with a crosswalk between them.]

During SMALL GROUP

Support Productive Struggle in Learning Mathematics

Q: Do you see any types of special angles in the diagram? [Yes, there are linear pairs and pairs of vertical angles.]

Q: Without knowing the measures of the angles, what relationships do you think *might* exist between certain pairs of angles? [Some will be congruent, such as the vertical angles. Some will be supplementary, such as the linear pairs.]

Q: How can you verify whether your conjectures are true? [Use a protractor to measure the angles.]

For Early Finishers

Q: In the diagram, ∠2 and ∠5 are on the same side of the transversal and each is above a parallel line. Describe the positions of the following angles with respect to the transversal and the parallel lines: ∠3 and ∠6; ∠1 and ∠7; ∠3 and ∠5. [opposite sides of the transversal, inside the parallel lines; opposite sides of the transversal, outside the parallel lines; same side of the transversal, inside the parallel lines]

After WHOLE CLASS

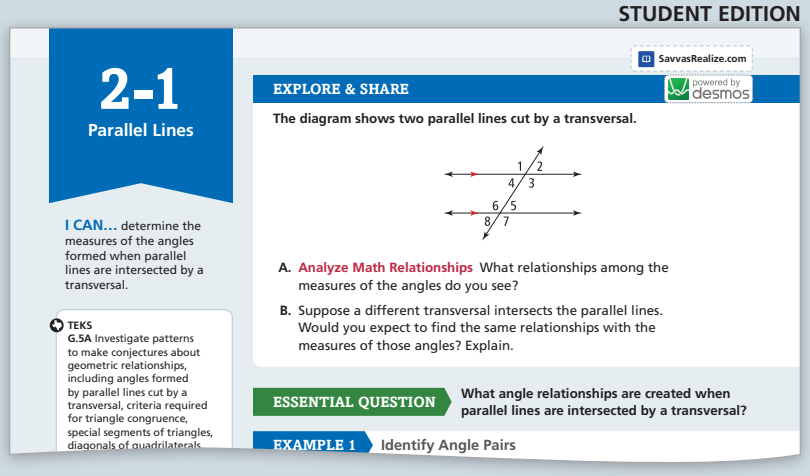
Facilitate Meaningful Mathematical Discourse

Ask students to share with the class what they wrote in Part B.

Q: How did you decide if the same relationships between the angles would still be true with another transversal? [Sample: Draw another transversal and measure the new angles formed. Repeat with several more transversals.]

Explore & Share is available at SavvasRealize.com.

STUDENT EDITION



2-1 Parallel Lines

I CAN... determine the measures of the angles formed when parallel lines are intersected by a transversal.

TEKS G.5A Investigate patterns to make conjectures about geometric relationships, including angles formed by parallel lines cut by a transversal, criteria required for triangle congruence, special segments of triangles, diagonals of quadrilaterals

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EXPLORE & SHARE

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The diagram shows two parallel lines cut by a transversal.

A. Analyze Math Relationships What relationships among the measures of the angles do you see?

B. Suppose a different transversal intersects the parallel lines. Would you expect to find the same relationships with the measures of those angles? Explain.

ESSENTIAL QUESTION What angle relationships are created when parallel lines are intersected by a transversal?

EXAMPLE 1 Identify Angle Pairs

SAMPLE RESPONSES

A. The measure of each angle is either 58° or 122°, so each pair of angles is either congruent or supplementary. The angles that form linear pairs are supplements and the vertical angles are congruent.

B. Yes; the measures of the angles might change because the slope of the new transversal might be different than the original one, but the pairs of angles should still be congruent, supplementary, or both.

PROCESS STANDARDS CONNECTION

Use with EXPLORE & SHARE

Analyze Math Relationships What theorems have you already learned that can be used to show why some of the angles formed are congruent?

[Sample: The Vertical Angles Theorem explains why vertical angles are congruent.]

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Activity

INTRODUCE THE ESSENTIAL QUESTION

Establish Mathematics Goals to Establish Learning

Students will learn the formal names for the types of angles formed when parallel lines are intersected by a transversal and prove that these angles are congruent, supplementary, or both.

EXAMPLE 1 Identify Angle Pairs

Pose Purposeful Questions

Q: How can you use the terms *same-side* and *exterior* to help you identify pairs of same-side exterior angles? [Sample: Look for two angles that are on the *same side* of the transversal and on the *exterior* of, or outside, the horizontal lines.]

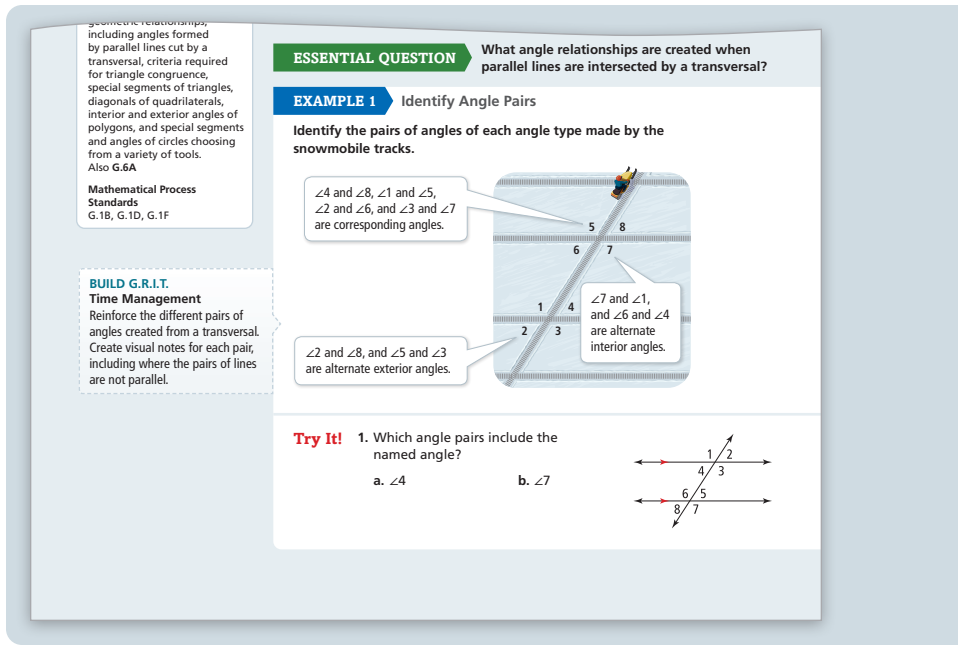
Q: What do you notice about the numbers of alternate interior angles, same-side exterior angles, and corresponding angles? [There are two pairs of alternate interior and same-side exterior angles and four pairs of corresponding angles.]

Try It! Answers

1. **a.** ∠4 and ∠6: same-side interior angles; ∠4 and ∠5: alternate interior angles; ∠4 and ∠8: corresponding angles

   b. ∠7 and ∠2: same-side exterior angles; ∠7 and ∠1: alternate exterior angles; ∠7 and ∠3: corresponding angles

Examples are available at SavvasRealize.com.


including angles formed by parallel lines cut by a transversal, criteria required for triangle congruence, special segments of triangles, diagonals of quadrilaterals, interior and exterior angles of polygons, and special segments and angles of circles choosing from a variety of tools. Also G.6A

Mathematical Process Standards G.1B, G.1D, G.1F

ESSENTIAL QUESTION What angle relationships are created when parallel lines are intersected by a transversal?

EXAMPLE 1 Identify Angle Pairs

Identify the pairs of angles of each angle type made by the snowmobile tracks.

∠4 and ∠8, ∠1 and ∠5, ∠2 and ∠6, and ∠3 and ∠7 are corresponding angles.

∠7 and ∠1, and ∠6 and ∠4 are alternate interior angles.

∠2 and ∠8, and ∠5 and ∠3 are alternate exterior angles.

BUILD G.R.I.T. Time Management Reinforce the different pairs of angles created from a transversal. Create visual notes for each pair, including where the pairs of lines are not parallel.

Try It! 1. Which angle pairs include the named angle?

a. ∠4 b. ∠7

Language Routine: Co-Craft Questions and Problems

After reading Example 1, invite students to develop their own questions and problems about pairs of equal angles. The problems can take either of two forms.

1. Name a pair of equal angles, using the numbers on the diagram in Example 1. Ask other students to say what kind of angle pair the two angles form: corresponding, alternate interior, or alternate exterior.
2. Name a kind of angle pair and ask other students to point to or name two angles that would fit the definition.

EXIT TICKET

Use this Exit Ticket anytime after Example 2.

ITEM	TEKS	DOK
1	G.6A	2
2	G.5A	2

Use the Exit Ticket results to inform instructional decisions.

Instructional Implications

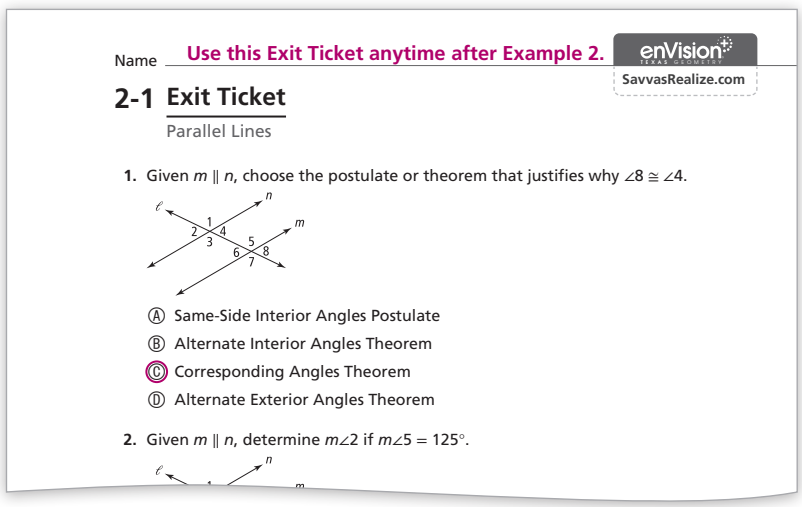
In Question 1, if students chose answer choice A, they may **NOT** have a clear understanding that the angles were on the same side of the transversal but misjudged that both angles were interior.

In Question 2, if students chose answer choice or C, they may **NOT** have a clear understanding that angles 2 and 5 were congruent or complementary. If they chose answer choice D, they may have thought the question called for the sum of angles 2 and 5.

As your instruction in parallel lines continues, plan to address common errors and misconceptions.

- Remind students that alternate exterior angles are outside the parallel lines, while alternate interior angles are between the parallel lines. Use Do You Know How item 5 or 6, if needed.

Formative Assessment The Exit Ticket is available at Savvas Realize® and in the Assessment Sourcebook.


Name Use this Exit Ticket anytime after Example 2.

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2-1 Exit Ticket

Parallel Lines

1. Given $m \parallel n$, choose the postulate or theorem that justifies why ∠8 ≅ ∠4.

Ⓐ Same-Side Interior Angles Postulate
Ⓑ Alternate Interior Angles Theorem
Ⓒ Corresponding Angles Theorem
Ⓓ Alternate Exterior Angles Theorem

2. Given $m \parallel n$, determine $m\angle 2$ if $m\angle 5 = 125°$.

- Remind them that a transversal cutting at an angle through two parallel lines creates four acute angles and four obtuse angles and that all the acute angles and all the obtuse angles have the same measure.

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Activity

EXAMPLE 2 Explore Angle Relationships

Build Procedural Fluency from Conceptual Understanding

Q: In the diagram for Postulate 2-1, do you see any other same-side interior angles?
[Yes, there is a pair on the opposite side of the transversal from ∠1 and ∠2.]

Q: What types of related angles do you see in the diagram that might help you find the measure of each angle?
[vertical angles, linear pairs, and same-side interior angles]

Q: What angle forms vertical angles with the given angle? What is its measure?
[∠7; $x°$; vertical angles are congruent.]

Q: What angles form a linear pair with the given angle? How can you find their measures?
[∠6 and ∠8; subtract $x°$ from 180°; angles that form a linear pair are supplementary.]

Q: What angle forms a pair of same-side interior angles with the given angle? How can you find its measure?
[∠2; subtract $x°$ from 180°; since the lines are parallel, the same-side interior angles are supplementary.]

Q: How can you find the measures of the remaining angles?
[Each remaining angle is congruent to either the given angle or to ∠2. You need to determine which of these each angle is congruent to, and then you will have found the measure of each angle.]

Try It! Answers

2. a. 118 or 62
b. 66

Elicit and Use Evidence of Student Thinking

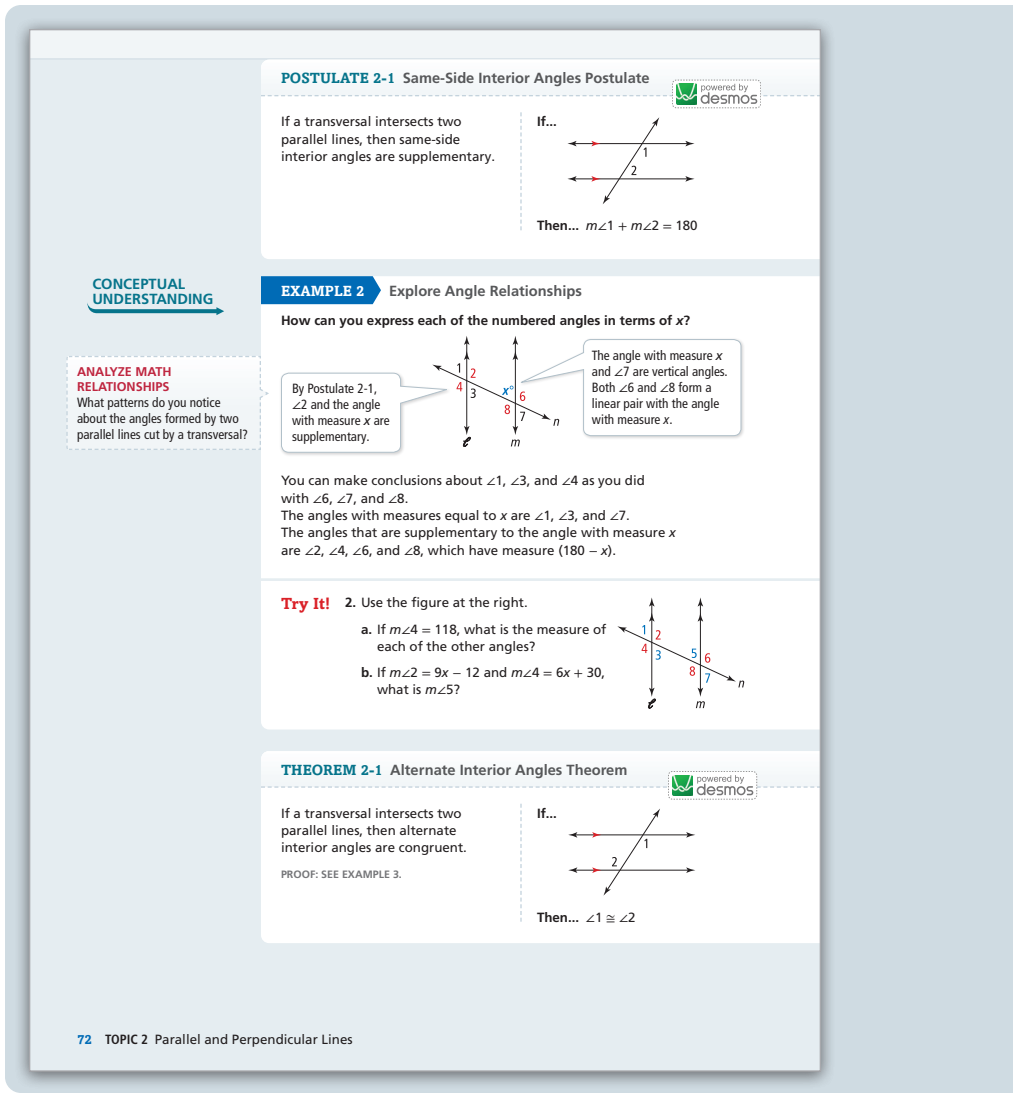
Q: What do you know about the measure of each angle in the figure?
[Each angle is either congruent to or supplementary to ∠4.]

Q: What angles are congruent to ∠4? What angles are supplementary to ∠4?
[∠2, ∠6, ∠8; ∠1, ∠3, ∠5, ∠7]

Common Error

Try It! 2 Students may have difficulty getting started because of the orientation of the parallel lines. If this is the case, have students rotate their books until the parallel lines appear horizontal. Remind students that, in general, the orientation of a figure does not affect the strategy they should use when solving a problem.

Postulate 2-1 and **Theorem 2-1** are Powered by Desmos. **Examples** are available at SavvasRealize.com.



POSTULATE 2-1 Same-Side Interior Angles Postulate

If a transversal intersects two parallel lines, then same-side interior angles are supplementary.

If...

Then... $m\angle 1 + m\angle 2 = 180$

CONCEPTUAL UNDERSTANDING

EXAMPLE 2 Explore Angle Relationships

How can you express each of the numbered angles in terms of x?

ANALYZE MATH RELATIONSHIPS
What patterns do you notice about the angles formed by two parallel lines cut by a transversal?

By Postulate 2-1, ∠2 and the angle with measure x are supplementary.

The angle with measure x and ∠7 are vertical angles. Both ∠6 and ∠8 form a linear pair with the angle with measure x.

You can make conclusions about ∠1, ∠3, and ∠4 as you did with ∠6, ∠7, and ∠8.
The angles with measures equal to x are ∠1, ∠3, and ∠7.
The angles that are supplementary to the angle with measure x are ∠2, ∠4, ∠6, and ∠8, which have measure $(180 - x)$.

Try It! **2.** Use the figure at the right.
a. If $m\angle 4 = 118$, what is the measure of each of the other angles?
b. If $m\angle 2 = 9x - 12$ and $m\angle 4 = 6x + 30$, what is $m\angle 5$?

THEOREM 2-1 Alternate Interior Angles Theorem

If a transversal intersects two parallel lines, then alternate interior angles are congruent.

PROOF: SEE EXAMPLE 3.

If...

Then... $\angle 1 \cong \angle 2$

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Activity

EXAMPLE 3 Prove the Alternate Interior Angles Theorem

Implement Tasks that Promote Reasoning and Problem Solving

Q: In the diagram for Example 3, why do you think ∠3 is labeled?
[Sample: Any angle that might help with the proof can be labeled.]

Q: How is ∠3 related to ∠1? How is ∠3 related to ∠2?
[∠3 and ∠1 are same-side interior angles; ∠3 and ∠2 form a linear pair.]

Q: What is unique about the location of ∠3? Can the same be said for any other angles in the diagram?
[Sample: It is supplementary to ∠1 and to ∠2. The angle that forms a pair of same-side interior angles with ∠2 is also supplementary to ∠1 and to ∠2.]

Try It! Answer

3. You are given $m \parallel n$. By the Angle Addition Postulate, $m\angle 1 + m\angle 3 = 180$, and by the Same-Side Interior Angles Postulate, $m\angle 2 + m\angle 3 = 180$. So $m\angle 1 + m\angle 3 = m\angle 2 + m\angle 3$ by the Transitive Property of Equality. By the Subtraction Property of Equality, $m\angle 1 = m\angle 2$, so $\angle 1 \cong \angle 2$ by the definition of congruence.

Elicit and Use Evidence of Student Thinking

Q: In the Try It!, how can you use ∠3 to help you prove the Corresponding Angles Theorem?
[You can use its relationships to ∠1 and ∠2. ∠3 and ∠1 form a linear pair and by that definition are supplementary; ∠3 and ∠2 are same-side interior angles and by Postulate 2-1 are supplementary.]

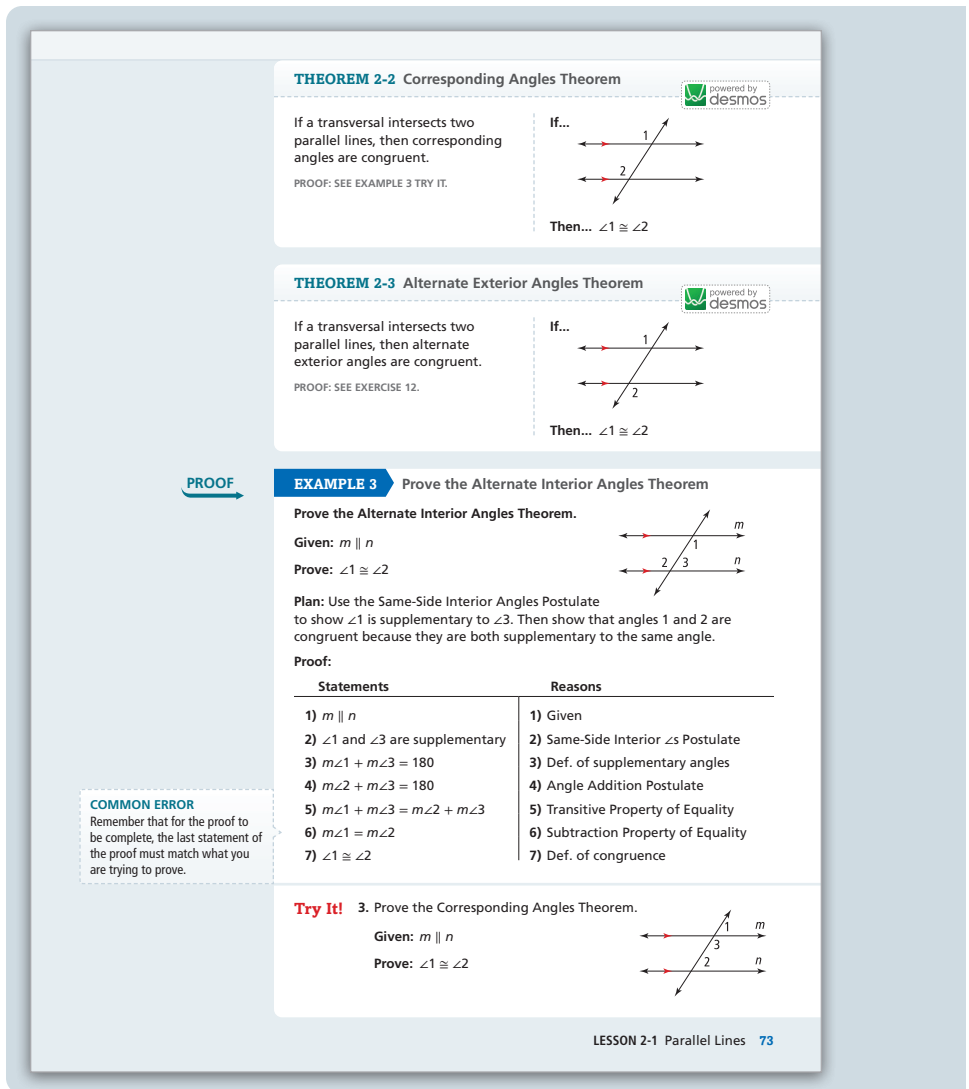
PROCESS STANDARDS CONNECTION

Use with EXAMPLES 1, 2, & 3

Apply Math Suppose that a transversal intersects a pair of parallel lines and one of the angles created measures x. What must be true of the other interior angles that are formed?

[They must measure x or $(180 - x)$.]

Theorems 2-2 and **2-3** are Powered by Desmos.
Examples are available at SavvasRealize.com.



THEOREM 2-2 Corresponding Angles Theorem

If a transversal intersects two parallel lines, then corresponding angles are congruent.

PROOF: SEE EXAMPLE 3 TRY IT.

If... Then... $\angle 1 \cong \angle 2$

THEOREM 2-3 Alternate Exterior Angles Theorem

If a transversal intersects two parallel lines, then alternate exterior angles are congruent.

PROOF: SEE EXERCISE 12.

If... Then... $\angle 1 \cong \angle 2$

PROOF

EXAMPLE 3 Prove the Alternate Interior Angles Theorem

Prove the Alternate Interior Angles Theorem.

Given: $m \parallel n$

Prove: $\angle 1 \cong \angle 2$

Plan: Use the Same-Side Interior Angles Postulate to show ∠1 is supplementary to ∠3. Then show that angles 1 and 2 are congruent because they are both supplementary to the same angle.

Proof:

Statements	Reasons
1) $m \parallel n$	1) Given
2) ∠1 and ∠3 are supplementary	2) Same-Side Interior ∠s Postulate
3) $m\angle 1 + m\angle 3 = 180$	3) Def. of supplementary angles
4) $m\angle 2 + m\angle 3 = 180$	4) Angle Addition Postulate
5) $m\angle 1 + m\angle 3 = m\angle 2 + m\angle 3$	5) Transitive Property of Equality
6) $m\angle 1 = m\angle 2$	6) Subtraction Property of Equality
7) $\angle 1 \cong \angle 2$	7) Def. of congruence

COMMON ERROR
Remember that for the proof to be complete, the last statement of the proof must match what you are trying to prove.

Try It! 3. Prove the Corresponding Angles Theorem.

Given: $m \parallel n$

Prove: $\angle 1 \cong \angle 2$

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Targeted ELPS Support SPEAKING 2B

(*Use with* EXAMPLE 3)

PRE-PRODUCTION Point to the term *alternate* in the Example title. Explain that *alternate* can be a verb, meaning to act or do by turns. Here, alternate is an adjective, meaning something related to every other one in a series. Read the example text and have students give a thumbs up each time you say the word *alternate*.

BEGINNING Point out the term *alternate* in the Example title. Explain that *alternate* can be a verb, meaning to act or do by turns. It can also be a noun, meaning a person acting in the place of another or a substitute. Here, alternate is an adjective, meaning something related to every other one in a series. Read the example text. Have students point to the two angles the proof will prove as alternate interior angles (1 and 2).

INTERMEDIATE Discuss the prefix *inter-*, which means inside. Point out that the prefix *exter-* means outside. Explain why the terms *interior* and *exterior* are used in relation to parallel lines. Ask: Why do the interior and exterior parts of the theorem names refer to parallel lines and not transversal lines? [Two lines are needed to create a space inside and a space outside.]

HIGH INTERMEDIATE Have students work in small groups to discuss the prefix *inter-* (which means inside) and the prefix *exter-* (which means outside). Ask students why the terms *interior* and *exterior* are used in relation to parallel lines. Ask: What do inter- and exter- appear to mean? [inside and outside] Ask: Why do the interior and exterior parts of the theorem names refer to parallel lines and not transversal lines? [Two lines are needed to create a space inside and a space outside.]

ADVANCED Have students review the meanings of the words *congruent* and *supplementary*. Then, have students work in pairs. One student uses the numbers to name any two angles in the Example 3 diagram. Then, the other student says whether the two angles are congruent or supplementary and if congruent what kind of pair they are.

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EXAMPLE 4 Use Parallel Lines to Prove an Angle Relationship

Support Productive Struggle in Learning Mathematics

Q: You are given $\overline{AC} \parallel \overline{DF}$ and $\overline{BE} \perp \overline{DF}$. What conclusions can you draw from these pieces of information?
[Same-side interior angles are supplementary; alternate interior angles, corresponding angles, and alternate exterior angles are congruent. ∠BED and ∠BEF are right angles, so $m\angle BED = m\angle BEF = 90$.]

Q: Explain the placement of Statement 5
[Statement 5 is the given information, which is usually listed as the first statement of a proof. It is placed here because it is used in combination with Statement 4 to produce Statement 6.]

Try It! Answer

4. $m\angle 1 + m\angle ACD = 180$ by the Same-Side Interior Angles Post., and $m\angle ACD = m\angle 3 + m\angle 4$ by the Angle Add. Post. By the Subst. Prop. of Equ., $m\angle 1 + m\angle 3 + m\angle 4 = 180$. $\angle 2 \cong \angle 4$ by the Alt. Int. Angles Thm., so $m\angle 2 = m\angle 4$ by the definition of congruence. By the Subst. Prop. of Equ., $m\angle 1 + m\angle 3 + m\angle 2 = 180$, so $m\angle 1 + m\angle 2 + m\angle 3 = 180$ by the Comm. Prop. of Add.

EXAMPLE 5 Find Angle Measures

Elicit and Use Evidence of Student Thinking

Q: What strategy might help you solve this type of problem?
[Sample: Redraw only the intersecting lines from the diagram, and label the lines and angles with the given information.]

Try It! Answer

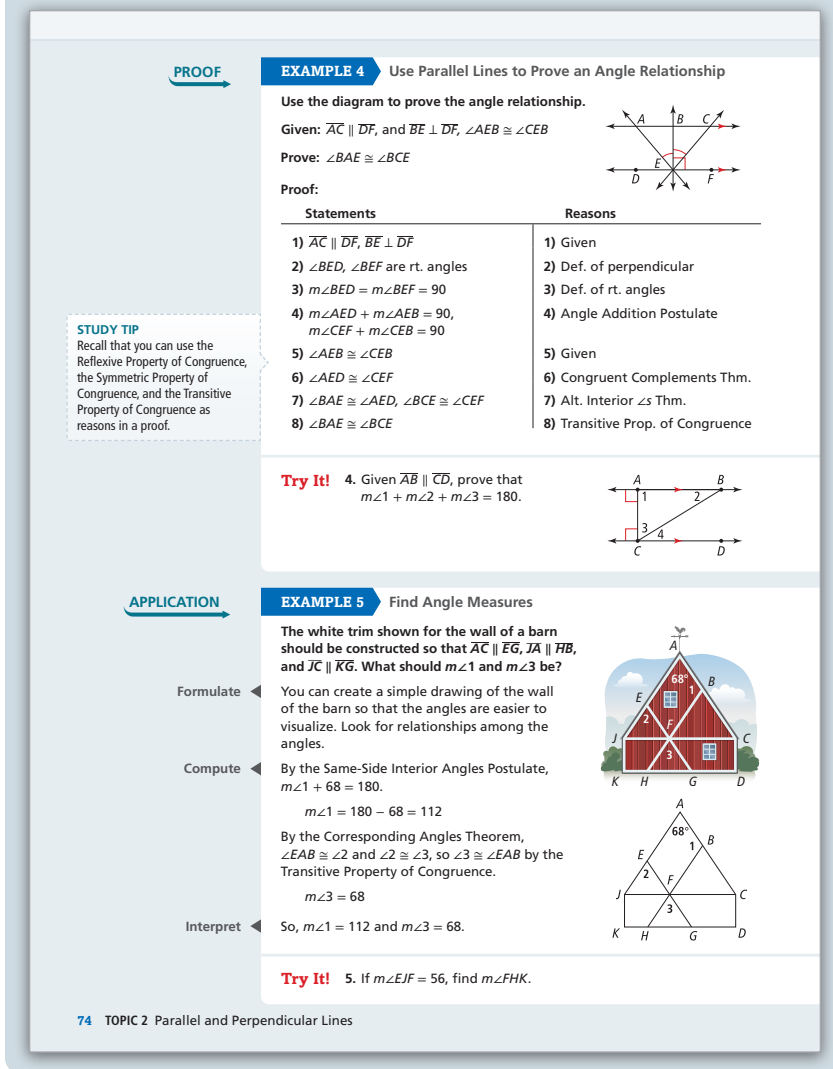
5. 124

PROCESS STANDARDS CONNECTION *Use with* EXAMPLES 4 & 5

Connect Math Ideas What are some strategies you can use to find unknown angle measures?

[Sample: Look for parallel lines and transversals, and find special angle pairs; look for linear pairs; look for vertical angles.]

Examples are available at SavvasRealize.com.



PROOF

EXAMPLE 4 Use Parallel Lines to Prove an Angle Relationship

Use the diagram to prove the angle relationship.

Given: $\overline{AC} \parallel \overline{DF}$, and $\overline{BE} \perp \overline{DF}$, $\angle AEB \cong \angle CEB$

Prove: $\angle BAE \cong \angle BCE$

Proof:

Statements	Reasons
1) $\overline{AC} \parallel \overline{DF}$, $\overline{BE} \perp \overline{DF}$	1) Given
2) $\angle BED$, $\angle BEF$ are rt. angles	2) Def. of perpendicular
3) $m\angle BED = m\angle BEF = 90$	3) Def. of rt. angles
4) $m\angle AED + m\angle AEB = 90$, $m\angle CEF + m\angle CEB = 90$	4) Angle Addition Postulate
5) $\angle AEB \cong \angle CEB$	5) Given
6) $\angle AED \cong \angle CEF$	6) Congruent Complements Thm.
7) $\angle BAE \cong \angle AED$, $\angle BCE \cong \angle CEF$	7) Alt. Interior ∠s Thm.
8) $\angle BAE \cong \angle BCE$	8) Transitive Prop. of Congruence

STUDY TIP
Recall that you can use the Reflexive Property of Congruence, the Symmetric Property of Congruence, and the Transitive Property of Congruence as reasons in a proof.

Try It! **4.** Given $\overline{AB} \parallel \overline{CD}$, prove that $m\angle 1 + m\angle 2 + m\angle 3 = 180$.

APPLICATION

EXAMPLE 5 Find Angle Measures

The white trim shown for the wall of a barn should be constructed so that $\overline{AC} \parallel \overline{EG}$, $\overline{JA} \parallel \overline{HB}$, and $\overline{JC} \parallel \overline{KG}$. What should $m\angle 1$ and $m\angle 3$ be?

Formulate: You can create a simple drawing of the wall of the barn so that the angles are easier to visualize. Look for relationships among the angles.

Compute: By the Same-Side Interior Angles Postulate, $m\angle 1 + 68 = 180$.

$m\angle 1 = 180 - 68 = 112$

By the Corresponding Angles Theorem, $\angle EAB \cong \angle 2$ and $\angle 2 \cong \angle 3$, so $\angle 3 \cong \angle EAB$ by the Transitive Property of Congruence.

$m\angle 3 = 68$

Interpret: So, $m\angle 1 = 112$ and $m\angle 3 = 68$.

Try It! **5.** If $m\angle EJF = 56$, find $m\angle FHK$.

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Support Student Understanding

USE WITH EXAMPLE 4 Struggling students may have difficulty understanding the presented proof.

- Walk through the proof, step by step, with students. Refer to the diagram, and ask the following questions.

Q: Look at Statement 3. How do you know $m\angle BED = m\angle BEF = 90$?
[It follows from the given information $\overline{BE} \perp \overline{DF}$.]

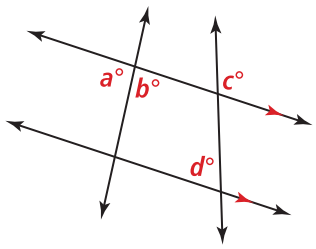
Q: Look at Statement 6. How many pairs of congruent alternate interior angles are there, and why are only these two pairs listed? [Three transversals intersect two parallel lines, forming six pairs of alternate interior angles. These two pairs are listed because they help connect $\angle BAE$ to $\angle BCE$.]

Extend Student Thinking

USE WITH EXAMPLE 5 Have advanced students find the measures of angles formed by parallel lines and transversals.

Q: What is the value of x if $a = x + 20$ and $b = x + 10$?
[75; The angles form a linear pair.]

Q: What is the value of y if $c = y$ and $d = y - 40$?
[110; The angles are supplements.]



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Presentation Practice

CONCEPT SUMMARY Parallel Lines and Angle Pairs

Pose Purposeful Questions

Q: When two parallel lines are cut by a transversal, how many pairs of same-side interior angles are formed? Alternate interior angles? Corresponding angles? Alternate exterior angles? [2; 2; 4; 2]

Q: When two parallel lines are cut by a transversal, how many angles are formed? How many different angle measures are there? Explain.
[8; 2, unless the transversal is perpendicular to the parallel lines, in which case there is only one angle measure, 90.]

Q: In your own words, summarize the angle relationships that exist when two parallel lines are cut by a transversal.
[Sample: If two parallel lines are cut by a transversal, then the pairs of same-side interior angles are supplementary, and the pairs of alternate interior angles, corresponding angles, and alternate exterior angles are congruent.]

Talk About Math Ideas

Encourage students to explore various angles created by a transversal and parallel lines. Have them distinguish differences and make note of them in practice with others.

Q: Think about the situation you discussed during the Explore & Share. What theorems could you use to identify angles in the figure which are supplementary or congruent?
[The Same-Side Interior Angles Postulate identifies supplementary angles. The Alternate Exterior Angles, Alternate Exterior Angles, and Corresponding angles Theorems identify congruent angle pairs.]

Do You UNDERSTAND? | Do You KNOW HOW?

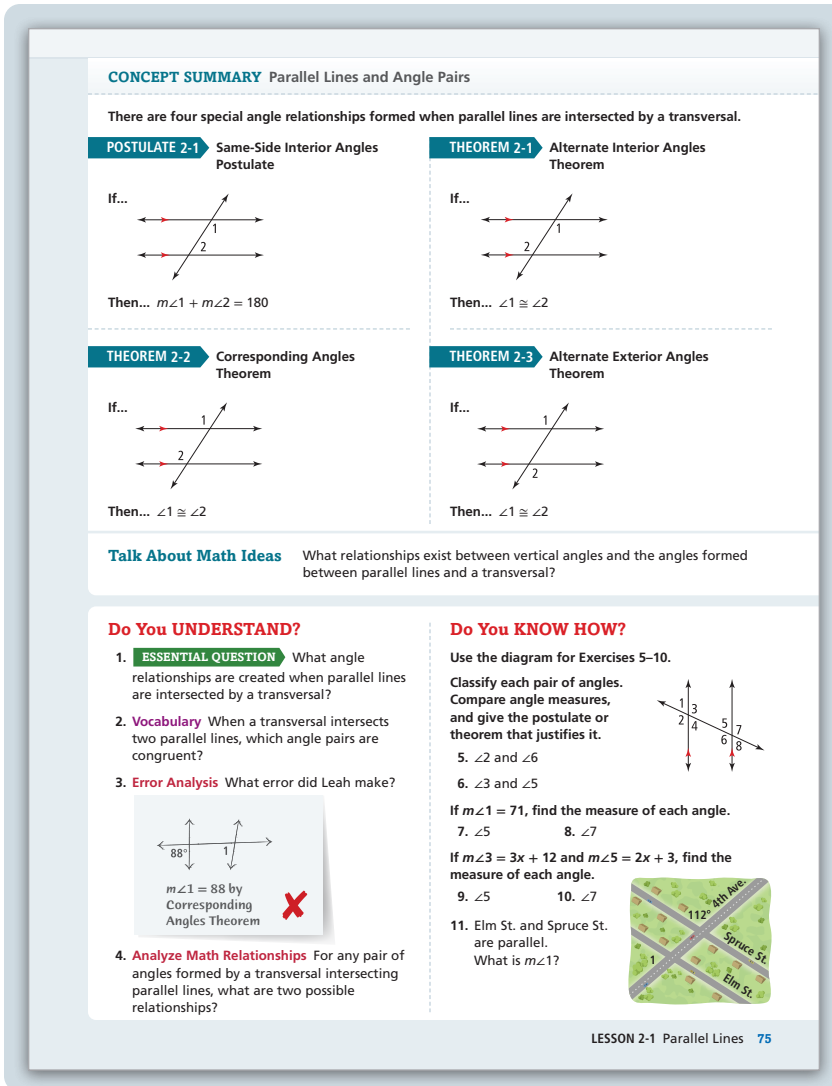
Common Error

Exercise 8 Because students did not learn a Same-Side Exterior Angles Theorem, they may have difficulty finding the measure of ∠7. Encourage these students to use a combination of definitions and theorems. For example, ∠1 ≅ ∠8 by the Alternate Exterior Angles Theorem, and ∠8 and ∠7 are supplementary because they form a linear pair. This should help students understand that ∠1 and ∠7 are also supplementary.

Answers

1. Corresponding, alternate interior, and alternate exterior angles are congruent. Same-side interior and same-side exterior angles are supplementary. The two types of congruent angles formed are supplementary to each other.
2. alternate interior angles, alternate exterior angles, corresponding angles, and vertical angles
3. Sample: Leah cannot use the theorem because it is not indicated that the lines intersected by the transversal are parallel.

Concept Summary, Do You Understand, and **Do You Know How** are available at SavvasRealize.com.



CONCEPT SUMMARY Parallel Lines and Angle Pairs

There are four special angle relationships formed when parallel lines are intersected by a transversal.

POSTULATE 2-1 Same-Side Interior Angles Postulate
If... Then... $m\angle 1 + m\angle 2 = 180$

THEOREM 2-1 Alternate Interior Angles Theorem
If... Then... $\angle 1 \cong \angle 2$

THEOREM 2-2 Corresponding Angles Theorem
If... Then... $\angle 1 \cong \angle 2$

THEOREM 2-3 Alternate Exterior Angles Theorem
If... Then... $\angle 1 \cong \angle 2$

Talk About Math Ideas What relationships exist between vertical angles and the angles formed between parallel lines and a transversal?

Do You UNDERSTAND?
1. ESSENTIAL QUESTION What angle relationships are created when parallel lines are intersected by a transversal?
2. Vocabulary When a transversal intersects two parallel lines, which angle pairs are congruent?
3. Error Analysis What error did Leah make? $m\angle 1 = 88$ by Corresponding Angles Theorem
4. Analyze Math Relationships For any pair of angles formed by a transversal intersecting parallel lines, what are two possible relationships?

Do You KNOW HOW?
Use the diagram for Exercises 5–10.
Classify each pair of angles. Compare angle measures, and give the postulate or theorem that justifies it.
5. ∠2 and ∠6
6. ∠3 and ∠5
If $m\angle 1 = 71$, find the measure of each angle.
7. ∠5 8. ∠7
If $m\angle 3 = 3x + 12$ and $m\angle 5 = 2x + 3$, find the measure of each angle.
9. ∠5 10. ∠7
11. Elm St. and Spruce St. are parallel. What is $m\angle 1$?

LESSON 2-1 Parallel Lines 75

4. The angles can be congruent or supplementary.
5. congruent, Corresponding Angles Theorem
6. supplementary, Same-Side Interior Angles Postulate
7. 71°
8. 109°
9. 69°
10. 111°
11. 68°

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Practice

PRACTICE & PROBLEM SOLVING

Practice & Problem Solving, Adaptive Practice and **Spiral Review** are available at SavvasRealize.com.

Space and Interleaved Practice You may opt to assign the automatically scored lesson digital Practice and Problem Solving or Spiral Review.

Assignment Guide

On-Level	Advanced
12, 14, 15, 17–26, 28–31	12–16, 20–31

Engage Through Student Choice

Go online for an assignment strategy.

Item Analysis

Example	Items	DOK	TEKS Content	TEKS Process
1	17–19	1	G.4B	
	27	2	G.4B	G.1D
2	15	2	G.4B	G.1B
	20, 28–30, 31	2	G.4B	
	14	3	G.4B	
3	21, 22	2	G.4B	
	12	3	G.4B	G.1D
4	23	3	G.4B	
5	16	2	G.4B	G.1F
	24	2	G.4B	
	13	3	G.4B	
	25, 26	3	G.4B	G.1B

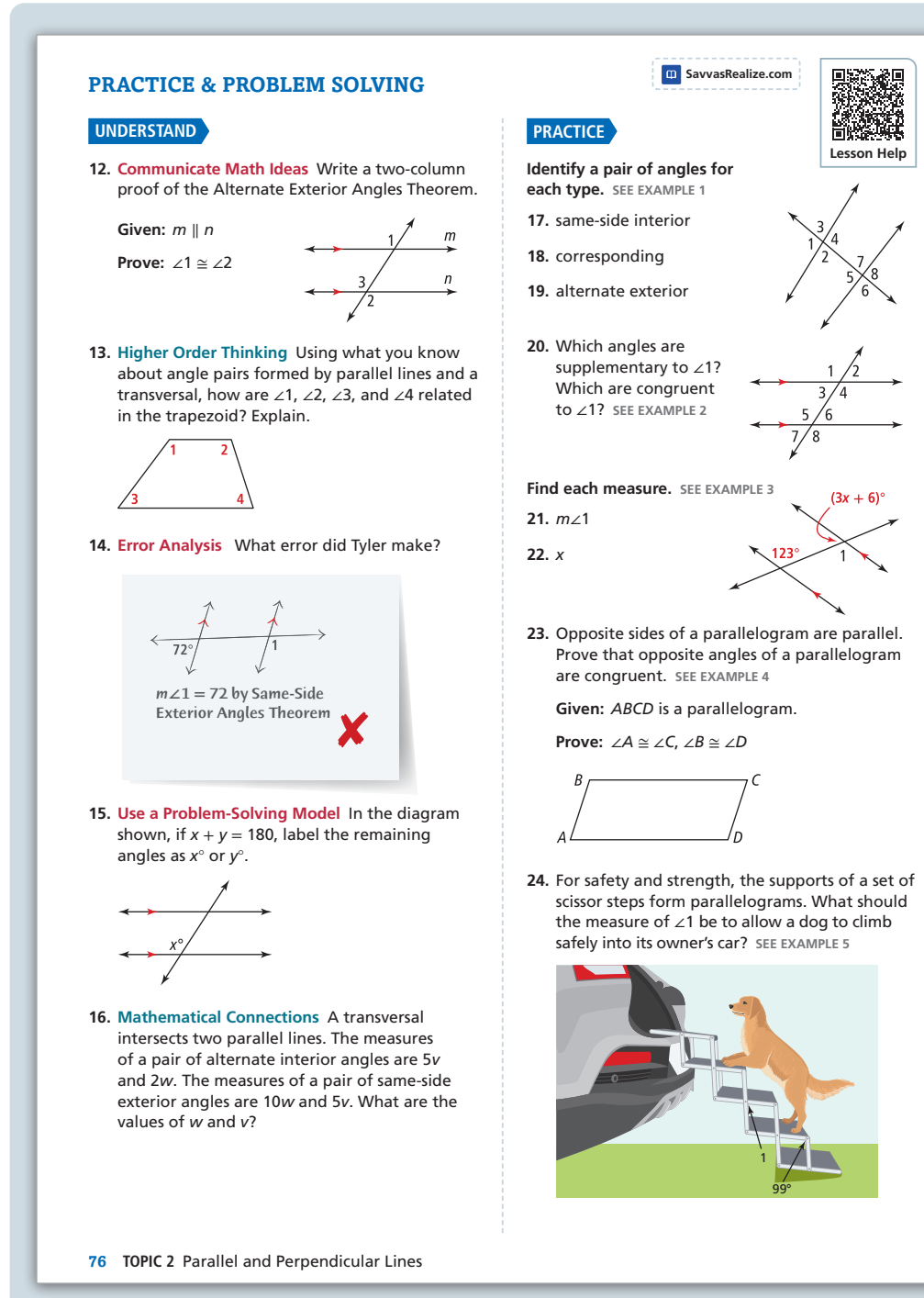
Answers

12. Sample:

Statements	Reasons
$m \parallel n$	Given
$\angle 1 \cong \angle 3$	Corresponding Angles Theorem
$\angle 3 \cong \angle 2$	Vertical Angles Theorem
$\angle 1 \cong \angle 2$	Transitive Property of Congruence

13. $\angle 1$ and $\angle 3$ are supplementary and $\angle 2$ and $\angle 4$ are supplementary because they are same-side interior angles.

14. While there is no Same-Side Exterior Angles Theorem given, same-side exterior angles are supplementary, not congruent. $m\angle 1 = 180 - 72 = 108$



PRACTICE & PROBLEM SOLVING

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Lesson Help

UNDERSTAND

12. **Communicate Math Ideas** Write a two-column proof of the Alternate Exterior Angles Theorem.

Given: $m \parallel n$

Prove: $\angle 1 \cong \angle 2$

13. **Higher Order Thinking** Using what you know about angle pairs formed by parallel lines and a transversal, how are $\angle 1$, $\angle 2$, $\angle 3$, and $\angle 4$ related in the trapezoid? Explain.

14. **Error Analysis** What error did Tyler make?

$m\angle 1 = 72$ by Same-Side Exterior Angles Theorem

15. **Use a Problem-Solving Model** In the diagram shown, if $x + y = 180$, label the remaining angles as $x°$ or $y°$.

16. **Mathematical Connections** A transversal intersects two parallel lines. The measures of a pair of alternate interior angles are $5v$ and $2w$. The measures of a pair of same-side exterior angles are $10w$ and $5v$. What are the values of w and v?

PRACTICE

Identify a pair of angles for each type. SEE EXAMPLE 1

17. same-side interior

18. corresponding

19. alternate exterior

20. Which angles are supplementary to $\angle 1$? Which are congruent to $\angle 1$? SEE EXAMPLE 2

Find each measure. SEE EXAMPLE 3

21. $m\angle 1$

22. x

23. Opposite sides of a parallelogram are parallel. Prove that opposite angles of a parallelogram are congruent. SEE EXAMPLE 4

Given: $ABCD$ is a parallelogram.

Prove: $\angle A \cong \angle C$, $\angle B \cong \angle D$

24. For safety and strength, the supports of a set of scissor steps form parallelograms. What should the measure of $\angle 1$ be to allow a dog to climb safely into its owner's car? SEE EXAMPLE 5

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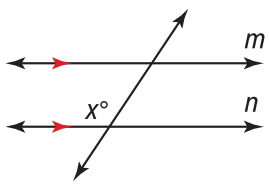
15.



16. $w = 15$, $v = 6$

17. Sample: $\angle 4$ and $\angle 7$

18. Sample: $\angle 7$ and $\angle 3$

19. Sample: $\angle 6$ and $\angle 3$

20. Angles 2, 3, 6, and 7 are supplementary. Angles 4, 5, and 8 are congruent.

21. 123

22. 17

See answers for Problems 23-24 on the next page.

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Practice

Answers

23.

Statements	Reasons
$\overline{AB} \parallel \overline{CD}$	Definition of parallelogram
$m\angle B + m\angle C = 180$ and $m\angle A + m\angle D = 180$	Same-Side Interior Angles Postulate
$\overline{BC} \parallel \overline{AD}$	Definition of parallelogram
$m\angle A + m\angle B = 180$ and $m\angle C + m\angle D = 180$	Same-Side Interior Angles Postulate
$m\angle A + m\angle B = m\angle B + m\angle C$	Trans. Prop. of Eq.
$m\angle A = m\angle C$	Subtr. Prop. of Eq.
$\angle A \cong \angle C$	Def. of congruence
$m\angle B + m\angle C = m\angle C + m\angle D$	Trans. Prop. of Eq.
$m\angle B = m\angle D$	Subtr. Prop. of Eq.
$\angle B \cong \angle D$	Def. of congruence

24. $m\angle 1 = 81$. In the parallelogram with the 99° angle, the adjacent angles are 81° by the Same-Side Interior Angles Postulate. In the parallelogram with $\angle 1$, the angle opposite $\angle 1$ is a vertical angle to one of the 81° angles, so the angle opposite $\angle 1$ is 81° by the Vertical Angles Theorem. By the Same-Side Interior Angles Postulate, the angles adjacent to $\angle 1$ must be 99°. Therefore, again, by the Same-Side Interior Angles Postulate, $m\angle 1 = 81$.

25. $y = 50$ because that angle and the labeled 50° angle are corresponding angles. The angles marked x and y are alternate interior angles, so $x = y = 50$.

26. $m\angle 1 = 61$ because it is a corresponding angle to $\angle 3$. Angles 1 and 2 are same-side interior angles, so they are supplementary. Therefore, $m\angle 2 = 180 - 61 = 119$.

27. **a.** 50°

b. corresponding angles; congruent

28. Minimum: 74°; Maximum: 79°

29. Angles 3, 6, and 8 are congruent to angle 1; angles 4, 5, and 7 are congruent to angle 2.

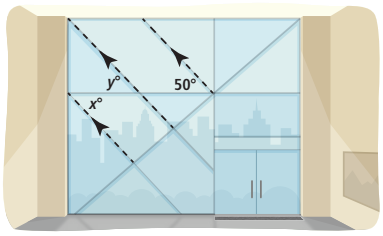
30. 62

Practice & Problem Solving, Adaptive Practice, and **Spiral Review** are available at SavvasRealize.com.

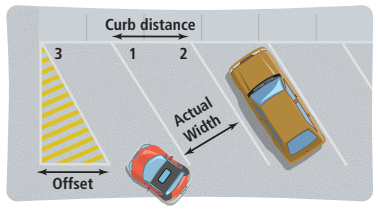
PRACTICE & PROBLEM SOLVING

APPLY

25. **Use a Problem Solving Model** A glazier is setting supports in parallel segments to prevent glass breakage during storms. What are the values of x and y? Justify your conclusions.



26. **Evaluate Reasonableness** In the parking lot shown, all of the lines for the parking spaces should be parallel. If $m\angle 3 = 61$, what should $m\angle 1$ and $m\angle 2$ be? Explain.

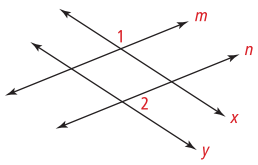


27. **Communicate Math Ideas** Margaret is in a boat traveling due west. She turned the boat 50° north of due west for a couple of minutes to get around a peninsula. Then she resumed due west again.

a. How many degrees would she turn the wheel to resume a due west course?

b. What type of angle pair did she use? Are the angles congruent or supplementary?

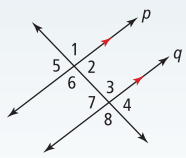
28. Parallel lines m and n intersect parallel lines x and y, representing two sets of intersecting railroad tracks. If the minimum measure for $\angle 1$ is 101° and the maximum measure for $\angle 1$ is 106°, what are the minimum and maximum measures for $\angle 2$?



ASSESSMENT PRACTICE

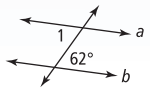
29. Classify each angle as *congruent to* $\angle 1$ or *congruent to* $\angle 2$. **G.5A**

Angle	Congruent to ∠1	Congruent to ∠2
∠3	☐	☐
∠4	☐	☐
∠5	☐	☐
∠6	☐	☐
∠7	☐	☐
∠8	☐	☐



30. **ACT** In the diagram, $a \parallel b$. What is $m\angle 1$?

Ⓐ 28 Ⓒ 90
Ⓑ 62 Ⓓ 118



31. **Performance Task** Students on a scavenger hunt are given the map shown and several clues. **G.6A**

Part A The first clue states the following:

Skyline Trail forms a transversal with Wood Path and Mission Path. Go to the corners that form same side exterior angles north of Skyline Trail.

Which two corners does the clue mean? Use intersections and directions to explain.

Part B The second clue states the following:

Wood and Mission Paths are parallel, and the northeast corner of Wood Path and Skyline Trail forms a 131° angle at trail marker M. Start at trail marker M and go to an equivalent exterior angle. Where are you now?

LESSON 2-1 Parallel Lines 77

31. **Part A** the northwest corner of Skyline Trail and Mission Path and the northeast corner of Skyline Trail and Wood Path

Part B the southwest corner of Skyline Trail and Mission Path

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Assessment

QUICK CHECK

Use the Quick Check to assess students' understanding of the mathematics in the lesson.

Students can take the Quick Check online where it will be automatically scored and appropriate differentiated practice will be assigned based on student performance. Or, you can download a printable copy from **SavvasRealize.com**. The Quick Check is also available in the *Assessment Sourcebook*.

Item Analysis

Item	DOK	Skills Review and Practice	Standards
1	2	G12	**G.6A**
2	3	G12	**G.6A**
3	3	G12	**G.6A**
4	3	G12	**G.6A**
5	2	G12	**G.5A**

DIFFERENTIATED RESOURCES

Points	Practice
0–3 points	• Reteach to Build Understanding • Mathematical Literacy and Vocabulary • Lesson Student Tutorial Videos
4–5 points	• Additional Practice • Enrichment

Quick Check is available at SavvasRealize.com.

ASSESSMENT RESOURCES

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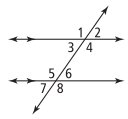
2-1 Quick Check

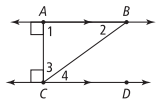
Properties of Parallel Lines

1. Select all the true statements.



- ☐ **A.** $\angle 3 \cong \angle 2$ because they are alternate interior angles.
- ■ **B.** $m\angle 1 + m\angle 3 = 180$ because they form a straight angle.
- ■ **C.** $\angle 3 \cong \angle 6$ because they are alternate interior angles.
- ■ **D.** $\angle 1$ and $\angle 6$ are supplementary because $\angle 3 \cong \angle 6$ and $m\angle 1 + m\angle 3 = 180$.
- ☐ **E.** $\angle 1 \cong \angle 3$ because they are vertical angles.

Use the figure shown for Items 2–4.



2. What is $m\angle 2 + m\angle 3$? Explain.

Ⓐ 180; $m\angle 1 + 90 = 180$, so $m\angle 2 + m\angle 3 = 180$.
Ⓑ 180; $m\angle 1 + 90 = m\angle 2 + m\angle 3$, so $m\angle 2 + m\angle 3 = 180$.
Ⓒ 90; $m\angle 1 + m\angle 2 + m\angle 3 = 180$. $m\angle 1 = 90$, so $m\angle 2 + m\angle 3 = 90$.
Ⓓ 90; $\angle 2$ and $\angle 3$ are corresponding angles, so $m\angle 2 + m\angle 3 = 90$.

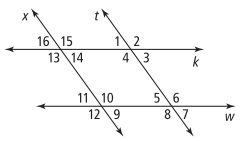
3. If $m\angle 4 = 35$, find $m\angle 2$. Explain.

Ⓐ 55; $\angle 2$ and $\angle 4$ are complementary angles, so $m\angle 2 = 90 - m\angle 4$.
Ⓑ 35; $\angle 2$ and $\angle 4$ are corresponding angles, so $m\angle 2 = m\angle 4$.
Ⓒ 145; $\angle 2$ and $\angle 4$ are supplementary angles, so $m\angle 2 = 180 - m\angle 4$.
Ⓓ 35; $\angle 2$ and $\angle 4$ are alternate interior angles, so $m\angle 2 = m\angle 4$.

4. If $m\angle 4 = 35$, find $m\angle 3$. Explain.

Ⓐ 55; $\angle 3$ and $\angle 4$ are complementary angles, so $m\angle 3 = 90 - m\angle 4$.
Ⓑ 35; $\angle 3$ and $\angle 4$ are corresponding angles, so $m\angle 3 = m\angle 4$.
Ⓒ 145; $\angle 3$ and $\angle 4$ are supplementary angles, so $m\angle 3 = 180 - m\angle 4$.
Ⓓ 35; $\angle 3$ and $\angle 4$ are alternate interior angles, so $m\angle 3 = m\angle 4$.

5. In the figure shown, $t \parallel x$ and $k \parallel w$. If $m\angle 3 = 20$, choose the list which includes all of the other angles that measure 20°.



Ⓐ 1
Ⓑ 7, 9, 14
Ⓒ 1, 14, 16
Ⓓ 1, 5, 7, 9, 11, 14, 16

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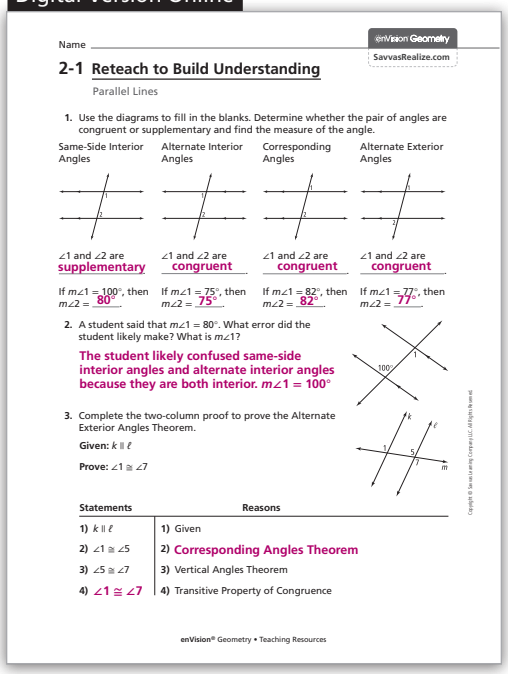
Practice

DIFFERENTIATED RESOURCES

Reteach to Build Understanding

Provides scaffolded reteaching for the key lesson concepts.

Digital Version Online



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2-1 Reteach to Build Understanding

Parallel Lines

1. Use the diagrams to fill in the blanks. Determine whether the pair of angles are congruent or supplementary and find the measure of the angle.

Same-Side Interior Angles	Alternate Interior Angles	Corresponding Angles	Alternate Exterior Angles
∠1 and ∠2 are **supplementary**.	∠1 and ∠2 are **congruent**.	∠1 and ∠2 are **congruent**.	∠1 and ∠2 are **congruent**.
If $m\angle1 = 100°$, then $m\angle2 =$ **80°**.	If $m\angle1 = 75°$, then $m\angle2 =$ **75°**.	If $m\angle1 = 82°$, then $m\angle2 =$ **82°**.	If $m\angle1 = 77°$, then $m\angle2 =$ **77°**.

2. A student said that $m\angle1 = 80°$. What error did the student likely make? What is $m\angle1$?
The student likely confused same-side interior angles and alternate interior angles because they are both interior. $m\angle1 = 100°$

3. Complete the two-column proof to prove the Alternate Exterior Angles Theorem.
Given: $k \parallel \ell$
Prove: $\angle1 \cong \angle7$

Statements	Reasons
1) $k \parallel \ell$	1) Given
2) $\angle1 \cong \angle5$	2) **Corresponding Angles Theorem**
3) $\angle5 \cong \angle7$	3) Vertical Angles Theorem
4) **$\angle1 \cong \angle7$**	4) Transitive Property of Congruence

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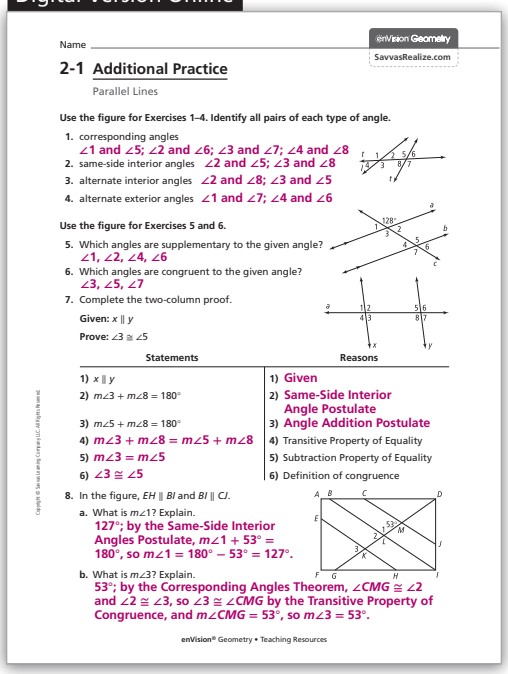
Additional Practice

Provides extra practice for each lesson.

Digital Version Online



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2-1 Additional Practice

Parallel Lines

Use the figure for Exercises 1–4. Identify all pairs of each type of angle.

1. corresponding angles
∠1 and ∠5; ∠2 and ∠6; ∠3 and ∠7; ∠4 and ∠8
2. same-side interior angles **∠2 and ∠5; ∠3 and ∠8**
3. alternate interior angles **∠2 and ∠8; ∠3 and ∠5**
4. alternate exterior angles **∠1 and ∠7; ∠4 and ∠6**

Use the figure for Exercises 5 and 6.

5. Which angles are supplementary to the given angle?
∠1, ∠2, ∠4, ∠6
6. Which angles are congruent to the given angle?
∠3, ∠5, ∠7
7. Complete the two-column proof.
Given: $x \parallel y$
Prove: $\angle3 \cong \angle5$

Statements	Reasons
1) $x \parallel y$	1) **Given**
2) $m\angle3 + m\angle8 = 180°$	2) **Same-Side Interior Angle Postulate**
3) $m\angle5 + m\angle8 = 180°$	3) **Angle Addition Postulate**
4) **$m\angle3 + m\angle8 = m\angle5 + m\angle8$**	4) Transitive Property of Equality
5) **$m\angle3 = m\angle5$**	5) Subtraction Property of Equality
6) **$\angle3 \cong \angle5$**	6) Definition of congruence

8. In the figure, $EH \parallel BI$ and $BI \parallel CJ$.
a. What is $m\angle1$? Explain.
127°; by the Same-Side Interior Angles Postulate, $m\angle1 + 53° = 180°$, so $m\angle1 = 180° - 53° = 127°$.
b. What is $m\angle3$? Explain.
53°; by the Corresponding Angles Theorem, $\angle CMG \cong \angle2$ and $\angle2 \cong \angle3$, so $\angle3 \cong \angle CMG$ by the Transitive Property of Congruence, and $m\angle CMG = 53°$, so $m\angle3 = 53°$.

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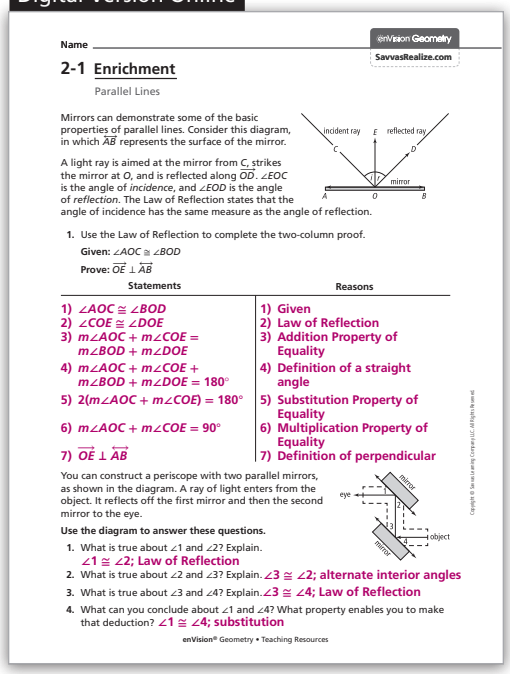
Enrichment

Presents engaging problems and activities that extend the lesson concepts.

Digital Version Online



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2-1 Enrichment

Parallel Lines

Mirrors can demonstrate some of the basic properties of parallel lines. Consider this diagram, in which $\overline{AB}$ represents the surface of the mirror.

A light ray is aimed at the mirror from C, strikes the mirror at O, and is reflected along $\overline{OD}$. $\angle EOC$ is the angle of *incidence*, and $\angle EOD$ is the angle of *reflection*. The Law of Reflection states that the angle of incidence has the same measure as the angle of reflection.

1. Use the Law of Reflection to complete the two-column proof.
Given: $\angle AOC \cong \angle BOD$
Prove: $\overleftrightarrow{OE} \perp \overline{AB}$

Statements	Reasons
1) **$\angle AOC \cong \angle BOD$**	1) **Given**
2) **$\angle COE \cong \angle DOE$**	2) **Law of Reflection**
3) **$m\angle AOC + m\angle COE = m\angle BOD + m\angle DOE$**	3) **Addition Property of Equality**
4) **$m\angle AOC + m\angle COE + m\angle BOD + m\angle DOE = 180°$**	4) **Definition of a straight angle**
5) **$2(m\angle AOC + m\angle COE) = 180°$**	5) **Substitution Property of Equality**
6) **$m\angle AOC + m\angle COE = 90°$**	6) **Multiplication Property of Equality**
7) **$\overleftrightarrow{OE} \perp \overleftrightarrow{AB}$**	7) **Definition of perpendicular**

You can construct a periscope with two parallel mirrors, as shown in the diagram. A ray of light enters from the object. It reflects off the first mirror and then the second mirror to the eye.

Use the diagram to answer these questions.

1. What is true about ∠1 and ∠2? Explain.
∠1 ≅ ∠2; Law of Reflection
2. What is true about ∠2 and ∠3? Explain. **∠3 ≅ ∠2; alternate interior angles**
3. What is true about ∠3 and ∠4? Explain. **∠3 ≅ ∠4; Law of Reflection**
4. What can you conclude about ∠1 and ∠4? What property enables you to make that deduction? **∠1 ≅ ∠4; substitution**

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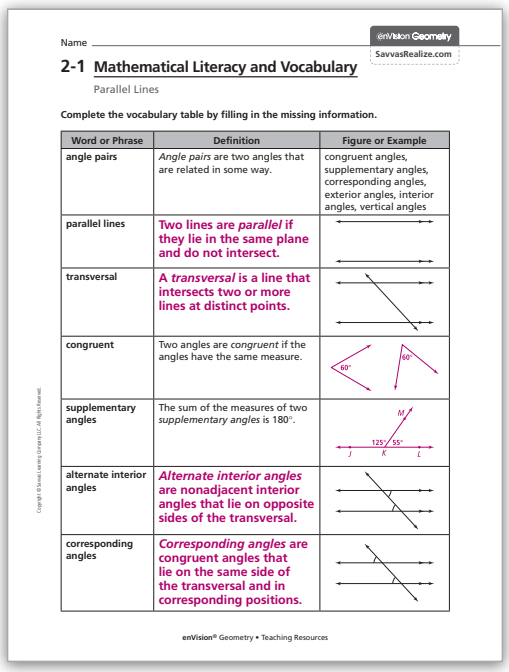
Mathematical Literacy and Vocabulary

Helps **emergent bilingual** students develop and reinforce understanding of key terms and concepts.



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2-1 Mathematical Literacy and Vocabulary

Parallel Lines

Complete the vocabulary table by filling in the missing information.

Word or Phrase	Definition	Figure or Example
angle pairs	*Angle pairs* are two angles that are related in some way.	congruent angles, supplementary angles, corresponding angles, exterior angles, interior angles, vertical angles
parallel lines	**Two lines are *parallel* if they lie in the same plane and do not intersect.**	
transversal	**A *transversal* is a line that intersects two or more lines at distinct points.**	
congruent	Two angles are *congruent* if the angles have the same measure.	
supplementary angles	The sum of the measures of two *supplementary angles* is 180°.	
alternate interior angles	***Alternate interior angles* are nonadjacent interior angles that lie on opposite sides of the transversal.**	
corresponding angles	***Corresponding angles* are congruent angles that lie on the same side of the transversal and in corresponding positions.**	

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Expand the Learning

You may choose to provide time in class for students to work on the **Pick a Project** that they selected. Provide the Teacher Resource Originals found on SavvasRealize.com to students based on the project they chose. Consider allowing time for students to share their projects before the end of the Topic.

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TOPIC 2

Math Modeling in 3 Acts: Parallel Paving Company

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Video / Audio

Lesson Overview

KEY CONCEPTS

Mathematics Objectives

- ✔ Use mathematical modeling to represent a problem situation and to propose a solution.
- ✔ Test and verify the appropriateness of their math models.
- ✔ Explain why the results from their mathematical models might not align exactly with the problem situation.

Language Objective

- ✔ Describe and solve a problem involving parallel and perpendicular lines using appropriate terms.

Essential Understanding

Many real-world problem situations can be represented with a mathematical model, but that model might not represent the real-world situation exactly.

COHERENCE

Earlier in this topic, students:

- Explored parallel and perpendicular lines.

In this lesson, students:

- Develop a mathematical model to represent and propose a solution to a problem situation involving parallel and perpendicular lines.

Later in this course, students will:

- Refine their mathematical modeling skills.

BALANCE

This mathematical modeling lesson focuses on application of both math content and math processes.

- Students draw on their understanding of concepts related to parallel and perpendicular lines to develop a representative model.
- Students apply their mathematical model to test and validate its applicability to similar problem situations.

Math Modeling in 3 Acts is Powered by Desmos.

MATH MODELING IN 3 ACTS

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Mathematical Process Standards
G.1A Apply mathematics to problems arising in everyday life, society, and the workplace.
TEKS
G.2B, G.2C

Parallel Paving Company

powered by desmos

Building roads consists of many different tasks. Once civil engineers have designed the road, they work with surveyors and construction crews to clear and level the land. Sometimes specialists have to blast away rock in order to clear the land. Once the land is leveled, the crews bring in asphalt pavers to smooth out the hot asphalt.

Sometimes construction crews will start work at both ends of the new road and meet in the middle. Think about this during the Math Modeling in 3 Acts lesson.

ACT 1

ACT 1 Identify the Problem

1. What is the first question that comes to mind after watching the video?
2. Write down the main question you will answer about what you saw in the video.
3. Make an initial conjecture that answers this main question.
4. Explain how you arrived at your conjecture.
5. What information will be useful to know to answer the main question? How can you get it? How will you use that information?

BUILD G.R.I.T. Resilience
If you need help, be open to ideas from your classmates. There are multiple ways to model the roads, and to draw conclusions.

ACT 2 Develop a Model

6. Use the math that you have learned in this Topic to refine your conjecture.

ACT 3 Interpret the Results

7. Did your refined conjecture match the actual answer exactly? If not, what might explain the difference?

104 TOPIC 2 Math Modeling in 3 Acts

Student Companion

Students can do their work for the task on their *Student Companion* pages, which you can print from **SavvasRealize.com**.

Texas Essential Knowledge and Skills (TEKS)

Mathematical Process Standards

The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to:

G.1A apply mathematics to problems arising in everyday life, society, and the workplace

Coordinate and transformational geometry. The student uses the process skills to understand the connections between algebra and geometry and uses the one- and two-dimensional coordinate systems to verify geometric conjectures. The student is expected to:

G.2B derive and use the distance, slope, and midpoint formulas to verify geometric relationships, including congruence of segments and parallelism or perpendicularity of pairs of lines. **Also G.2C**

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Video / Audio

Parallel Paving Company

In this mathematical modeling task, students will explore and apply concepts related to parallel and perpendicular lines. Students will analyze a situation involving paving pairs of roads with certain conditions. They will be tasked with determining whether pairs of lines are parallel, perpendicular, or neither. To do so, they apply concepts they study in Topic 2.

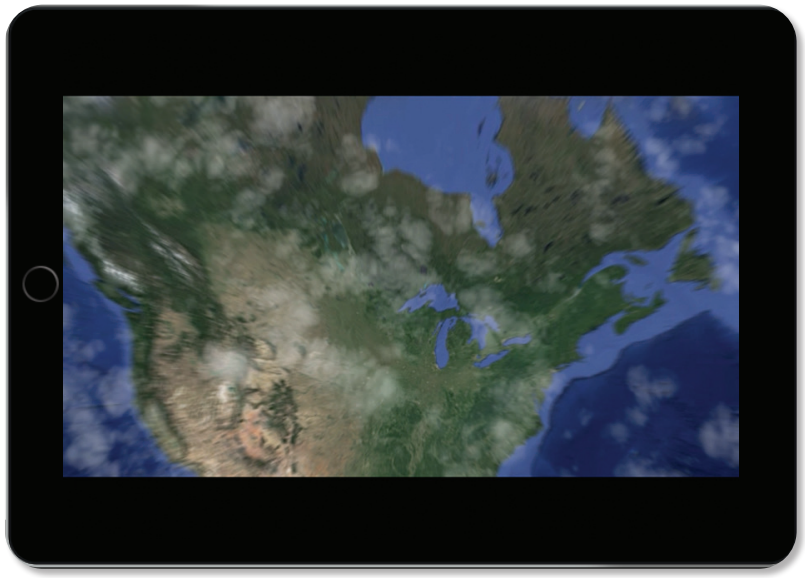
ACT 1 The Hook

Play the video. The video shows a paving company building roads on undeveloped land. We see the first few days' progress at each of the three sites.

After the question brainstorming, present to students the Main Question they will be tasked with answering. Remind students to write down their questions and conjectures.

MAIN QUESTION

Are these roads paved correctly? Are they really parallel or perpendicular?



ACT 2 Modeling With Math

Think about the task. Ask students to speculate how they can determine whether the lines are being paved correctly. Then have them think about what information they need.

Reveal the information. Use the tool, which overlays a coordinate grid on each site. Rather than provide students with coordinates for each road, encourage them to use the coordinate grids to find the information they need. Sample points, using the middle of each road, are provided at the right.

Students may not yet realize that the Day numbers in the video are not relevant to the Main Question.

What's the connection? Give students time to struggle as they think about how to connect their ideas to what they learned in this topic about parallel and perpendicular lines. Ask how they can use the information from the coordinate grids to answer the Main Question for each site.

INTERESTING MOMENTS WITH STUDENTS

Discuss with students what "paved correctly" means for each site. For the first site, it means that the roads should be parallel. For the second site, the roads should be perpendicular cross streets. The third site is one road, started from opposite ends, so it should meet in the middle.

Ask students for more points. If they're stuck, ask students to write down a third and fourth point on each line. Ask them to justify their responses, which may lead to a necessary discussion of slope.

Necessary Information

Sample Points

Site 1

Road 1 passes through (2, 1) and (5, 2).

Road 2 passes through (4, 9) and (11, 11).

Site 2

Road 1 passes through (5, 4) and (12, 5).

Road 2 passes through (13, 9) and (14, 2).

Site 3

Road 1 passes through (0, 8) and (4, 9).

Road 2 passes through (16, 13) and (20, 14).

The roads are straight and flat.
There are no obstacles in the way that would prevent the roads from continuing straight.

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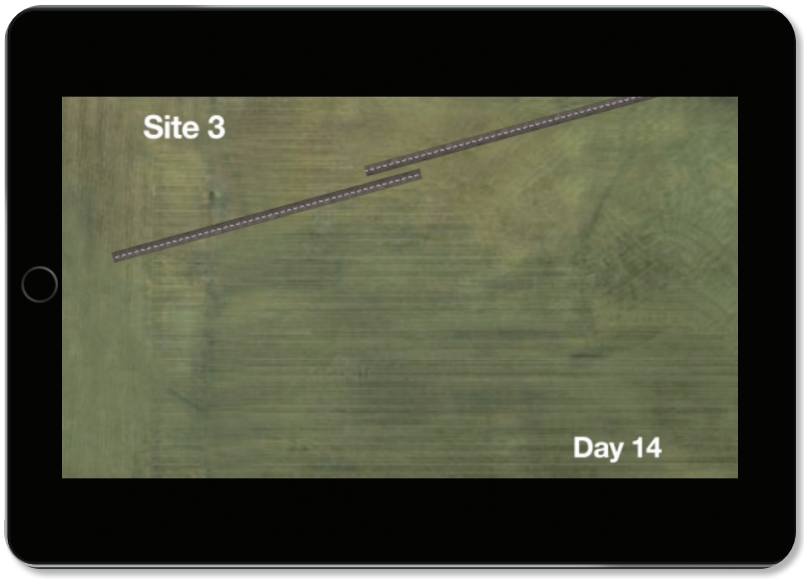
Video / Audio

ACT 3 The Solution

Play the video. The final video shows the completion of each of the three construction sites. It is revealed whether each road is paved correctly. Offer praise to the students whose conjectures are correct.



MAIN QUESTION ANSWER

Site 1: The roads are not parallel.

Site 2: The roads are perpendicular.

Site 3: The roads are parallel, and they will not meet.

Do the "post-game" analysis. Engage students in a discussion about possible reasons why the equations they wrote would not be perfect models for the paths of roads. The construction site may not be perfectly flat. It may be preferable to build a road around trees than to cut them down.

Now that the solution has been revealed and discussed, ask students to analyze and evaluate the efficiency of the approach they chose to solve the problem.

ONE POSSIBLE SOLUTION

The first pair of roads have slopes $\frac{2}{7}$ and $\frac{1}{3}$. They look nearly parallel but they are not. The paving company is paving the roads incorrectly.

The second pair of roads have slopes $\frac{1}{7}$ and -7. They are perpendicular. The paving company is paving the roads correctly.

The third set of roads both have slope $\frac{1}{4}$, so they are parallel. However, the equations for the third set of roads are $y = \frac{1}{4}x + 8$ and $y = \frac{1}{4}x + 9$, so they won't meet in the middle. The paving company is paving the roads incorrectly.

INTERESTING MOMENTS WITH STUDENTS

Roads have thickness that lines do not. Students may use the top edge of the roads, the middle line, or some other guide. Help them realize that the part they use affects the equations of the lines but does not affect the answer.

CREATE A PROBLEM

As students finish, ask them to create a problem with their own road design: a pair of roads that is perpendicular, another that is parallel, and a third that is neither parallel nor perpendicular. Have students trade problems with a partner and prove, without drawing, that each pair of roads meets the required condition. [Answers will vary. Check students' work.]

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