### 10.5 Frieze Patterns

**Objective** To guide the application of reflections, rotations, and translations.

#### 1 Teaching the Lesson

**Key Activities**
Students read about frieze patterns in which a design is repeatedly reflected, rotated, or translated to produce a pattern. They complete frieze patterns and create their own.

**Key Concepts and Skills**
- Identify and draw congruent figures. [Geometry Goal 2]
- Identify, describe, and sketch reflections, rotations, and translations. [Geometry Goal 3]
- Extend, describe, and create geometric patterns. [Patterns, Functions, and Algebra Goal 1]

**Key Vocabulary**
- frieze pattern
- reflection (flip)
- translation (slide)
- rotation (turn)

**Ongoing Assessment: Recognizing Student Achievement**
Use journal page 281.

#### 2 Ongoing Learning & Practice

Students play *Polygon Pair-Up* to practice identifying properties of polygons.

Students practice and maintain skills through Math Boxes and Study Link activities.

**Materials**
- Math Journal 2, p. 282
- Student Reference Book, p. 258
- Study Link Master (Math Masters, p. 318)
- *Polygon Pair-Up* Polygon Cards and Property Cards (Math Masters, pp. 496 and 497)

#### 3 Differentiation Options

**Readiness**
Students use pattern blocks to create and continue geometric patterns.

**Enrichment**
- Students explore different arrangements of four straws.
- Students use technology to explore tessellations.

**Extra Practice**
Students cut out a template and create frieze patterns.

**Materials**
- Teaching Master (Math Master, p. 319)
- Teaching Aid Masters (Math Masters, pp. 389 and 437)
- Geometry Template; straws; pattern blocks; computer with Internet access; index cards; scissors

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**Technology**

Assessment Management System
Journal page 281, Problem 1
See the ITLG.
See the Web site on page 821.
Getting Started

Math Message Follow-Up
(Student Reference Book, p. 108)

Ask students to describe what they notice about each of the frieze patterns on Student Reference Book, page 108. Have students indicate thumbs-up if they made a similar observation. The discussion should include the following points:

- Each pair of horses in the first frieze pattern is the same size and shape, but they face in opposite directions.
- The line of reflection for each pair of horses is a vertical line running through the center of the flower.
- Each elephant and horse in the second frieze pattern is the same size and shape and faces in the same direction.
- Each of the flowers in the third frieze pattern is the same size and shape but is turned in a different direction.

Tell students that in this lesson they will explore examples of frieze patterns to see how designs are created by repeatedly moving figures in three different ways: reflections, translations, and rotations.

Introducing Frieze Patterns
(Student Reference Book, p. 108)

The examples of frieze patterns on Student Reference Book, page 108 provide an initial exposure to “rigid motions,” in which objects retain their shape as they are moved in various ways.
Through work in the preceding lessons, students should be familiar with **reflections**. (The top frieze on *Student Reference Book*, page 108 was created by reflecting the horse repeatedly across vertical lines of reflection.) The second frieze is an example of another rigid motion—a **translation**, or slide, in which a shape is moved without being turned or flipped. To support English language learners, discuss the everyday and mathematical uses of the word **translation**.

Students should observe a difference between the first and second friezes: In the first frieze, the design is repeated so that alternating designs face in opposite directions. In the second frieze, the designs all face in the same direction.

The third frieze on the *Student Reference Book* page combines slides, flips, and turns in a complex design.

Overhead or regular pattern blocks also can be used to illustrate rigid motions. For example, the pattern below was made by a **rotation** of each figure 90° clockwise, followed by a translation of the figure to the right.

A pattern made by rotations and translations

**Drawing Frieze Patterns**

(*Math Journal 2*, p. 281)

**Art Link** Students complete three frieze patterns on journal page 281 and design one of their own.

**Adjusting the Activity**

Have students sketch the original design for each frieze pattern on centimeter grid paper (*Math Masters*, page 403). They can use a transparent mirror to check their reflections for Problem 1a and slide and rotate the paper to check their patterns for Problems 1b and 1c.

**Ongoing Assessment: Recognizing Student Achievement**

Use journal page 281, Problem 1 to assess students’ ability to identify and sketch an example of a reflection and identify examples of translations and rotations. Students are making adequate progress if they are able to continue the pattern in Problem 1a and identify the transformations in Problems 1a–1c. Some students may be able to sketch the translations and rotations in Problems 1b and 1c.

[Geometry Goal 3]
Playing Polygon Pair-Up
(Student Reference Book, p. 258; Math Masters, pp. 496 and 497)

Students play Polygon Pair-Up to practice identifying properties of polygons. See Lesson 1-6 for additional information.

Math Boxes 10-5
(Math Journal 2, p. 282)

Mixed Practice Math Boxes in this lesson are paired with Math Boxes in Lesson 10-2. The skill in Problem 5 previews Unit 11 content.

Writing/Reasoning Have students write a response to the following: Calculate the mean number of hours Julia babysat last week and explain your strategy. Sample answer: I added the hours she babysat each day (4 + 2 1/2 + 1 + 1 1/2 + 3 = 12) and divided by 5 for the number of days. 12 / 5 = 2 2/5 hours, or 2 hours 24 minutes.

Study Link 10-5
(Math Masters, p. 318)

Home Connection Students extend geometric patterns and create patterns of their own.

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### Math Journal 2, p. 282

**Math Boxes**

1. Complete the table with equivalent names.

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Decimals</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/10</td>
<td>0.10</td>
<td>10%</td>
</tr>
<tr>
<td>1/4</td>
<td>0.25</td>
<td>25%</td>
</tr>
</tbody>
</table>

2. Write the decimal point in each quotient.

   a. 714 ÷ 4 = 187
   b. 6.9 ÷ 0.25 = 27.6
   c. 0.1 ÷ 3 = 0.033
   d. 2 ÷ 4.2 = 0.476

3. Julia babysat for the family next door. Below are the hours she worked.
   - Monday: 4 hours
   - Tuesday: 2 1/2 hours
   - Wednesday: 1 hour
   - Thursday: 1 1/2 hours
   - Friday: 3 hours
   Use this data to create a bar graph.

4. Use the data to create a bar graph.

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**Study Link 10-5**

1. Continue each pattern. Then tell if you continued the pattern by using a reflection, rotation, or translation of the original design.

   a. reflection
   b. translation
   c. rotation


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**Study Link Master**

**Geometric Patterns**

1. a. 50% of $55.00 = $27.50
   b. 40% of $105.00 = $42.00
   c. 25% of $100.00 = $25.00
   d. 50% of $200.00 = $100.00

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**Math Masters, p. 318**
3 Differentiation Options

READINESS

Exploring Geometric Patterns

*(Math Masters, p. 389)*

Art Link To explore geometric patterns using a concrete model, have students create and continue patterns using pattern blocks. One student begins a pattern. The other students in the group take turns continuing the pattern.

A group drawing can be made of some of the patterns by tracing the blocks or using the Geometry Template. On an Exit Slip, have students describe how they created their pattern using words such as *slide, flip, or turn.*

ENRICHMENT

Exploring Arrangements of Four Straws

*(Math Masters, p. 437)*

To apply students’ understanding of congruence, reflections, and rotations, have them investigate 16 possible ways to arrange four straws. Explain the following:

- Each straw must connect to the end of at least one other straw, and the straws must connect to form either a straight angle or a right angle.

- A flipped or rotated figure cannot be counted as a different figure.

Have students record their figures on *Math Masters,* page 437 and explain the strategy they used to find them.
Exploring Tessellations

Technology Link To apply students’ understanding of reflections, rotations, and translations, have them use technology to explore tessellations. See the Web site at http://nlvm.usu.edu/en/nav/frames_asid_163_g_2_t_3.html?open=activities.

Discuss the following points:

- A tessellation is an arrangement of repeated, closed shapes that cover a surface so that no shapes overlap and there are no gaps between the shapes.

- Some tessellations repeat only one basic shape. Others combine two or more basic shapes. A regular tessellation is a tessellation made up of only one kind of regular polygon.

- In a tessellation, the basic shapes are reflected, rotated, or translated to fill the surface.

Ask students which of the regular polygons shown on the Web site can be used to create a regular tessellation. There are only three regular tessellations—equilateral triangle, square, and hexagon.

Links to the Future

Students will further explore regular tessellations in *Fifth Grade Everyday Mathematics*. Naming notation, semi-regular tessellations, and Escher-type translation tessellations are introduced in *Sixth Grade Everyday Mathematics*.

Creating Frieze Patterns

*(Math Masters, p. 319)*

Art Link To practice reflections, rotations, and translations, have students make frieze patterns by following the directions on *Math Masters*, page 319. Ask them to describe any reflections, translations, or rotations they use.

Making Frieze Patterns

1. Use an index card as a template for making frieze patterns.
   a. Trim your index card to make a 3-inch by 3-inch square.
   b. Draw a simple design in the middle of the square.
   c. Cut out your design. If you need to cut through the edge of the index card, then use tape to repair the cut.
   d. Move your template to the right along the line. Line up the left side of the template with the mark you made on the line.
   e. Repeat Steps c and d. To make more complicated patterns, give your template a turn or a flip every time you move it.