**Inquiry Lab**

**Area of Parallelograms**

**How does finding the area of a parallelogram relate to finding the area of a rectangle?**

**Banners** Elise wants to make a banner in the shape of a parallelogram. Her parallelogram has a base of 3 feet and a height of 2 feet. What is the area of her parallelogram?

**Investigation 1**

Another type of quadrilateral is a parallelogram. A parallelogram has opposite sides parallel and congruent.

<table>
<thead>
<tr>
<th>Parallelograms</th>
<th>Not Parallelograms</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Parallelogram" /></td>
<td><img src="image2.png" alt="Not Parallelogram" /></td>
</tr>
</tbody>
</table>

Make a parallelogram to represent Elise's banner.

**Step 1** Start with a rectangle. Trace the rectangle shown at the right.

![Rectangle](image3.png)

**Step 2** Cut a triangle from one side of the rectangle you traced and move it to the other side to form a parallelogram. Tape the parallelogram to the right.

![Parallelogram](image4.png)

The rectangle was rearranged to form the parallelogram. Nothing was removed or added, so the parallelogram has the same area as the rectangle.

**Step 3** Find the base and height of the parallelogram to find the area. The base of the parallelogram is 2 feet and the height is 3 feet.

\[ \text{base} \times \text{height} = \text{area} \]

\[ 2 \text{ feet} \times 3 \text{ feet} = \square \text{ square feet} \]
**Investigation 2**

Find the area of the parallelogram below.

**Step 1**  Trace the parallelogram on grid paper and cut it out.

**Step 2**  Fold and cut along the dotted line.

**Step 3**  Move the triangle to the right to make a rectangle. Tape the rectangle in the space provided.

**Step 4**  Count the number of square units in the rectangle.

The area is \( \square \) square units.

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**Investigation 3**

Find the area of the parallelogram below.

**Step 1**  Trace the parallelogram and cut it out.

**Step 2**  Fold and cut along the dotted line. Then move the triangle to the right to make a rectangle. Tape it in the space provided.

**Step 3**  Count the number of square units in the rectangle.

The area is \( \square \) square units.
Area parallelograms and Triangles

Collaborate

Use Math Tools Work with a partner. Find the area of each parallelogram.

1. \( A = \quad \text{square units} \)

2. \( A = \quad \text{square units} \)

3. \( A = \quad \text{square units} \)

4. \( A = \quad \text{square units} \)

5. \( A = \quad \text{square units} \)

6. \( A = \quad \text{square units} \)

7. \( A = \quad \text{square units} \)

8. \( A = \quad \text{square units} \)

Analyze

The table shows the dimensions of several rectangles and the corresponding dimensions of several parallelograms if each rectangle was rearranged to form a parallelogram. Work with a partner to complete the table. The first one is done for you.

<table>
<thead>
<tr>
<th>Rectangle</th>
<th>Length (l)</th>
<th>Width (w)</th>
<th>Parallelogram</th>
<th>Base (b)</th>
<th>Height (h)</th>
<th>Area (units²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectangle 1</td>
<td>6</td>
<td>3</td>
<td>Parallelogram 1</td>
<td>6</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Rectangle 2</td>
<td>12</td>
<td>4</td>
<td>Parallelogram 2</td>
<td>12</td>
<td>4</td>
<td>48</td>
</tr>
<tr>
<td>Rectangle 5</td>
<td>7</td>
<td>5</td>
<td>Parallelogram 3</td>
<td>7</td>
<td>5</td>
<td>35</td>
</tr>
<tr>
<td>Rectangle 4</td>
<td>5</td>
<td>4</td>
<td>Parallelogram 4</td>
<td>5</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Rectangle 5</td>
<td>10</td>
<td>6</td>
<td>Parallelogram 5</td>
<td>10</td>
<td>6</td>
<td>60</td>
</tr>
<tr>
<td>Rectangle 6</td>
<td>6</td>
<td>4</td>
<td>Parallelogram 6</td>
<td>6</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>Rectangle 7</td>
<td>25</td>
<td>9</td>
<td>Parallelogram 7</td>
<td>25</td>
<td>9</td>
<td>225</td>
</tr>
<tr>
<td>Rectangle 8</td>
<td>9</td>
<td>5</td>
<td>Parallelogram 8</td>
<td>9</td>
<td>5</td>
<td>45</td>
</tr>
</tbody>
</table>

18. A rectangle was rearranged to form a parallelogram. How is the height of the parallelogram similar to and different from the width of the rectangle?

19. Reason Inductively Write a rule that gives the area of a parallelogram.

Reflect

20. Reason Abstractly If you were to draw three different parallelograms each with a base of 6 units and a height of 4 units, how would the areas compare?

21. How does finding the area of a parallelogram relate to finding the area of a rectangle?
Area parallelograms and Triangles

Write this down!

Key Concept

Area of a Parallelogram

Words: The area $A$ of a parallelogram is the product of its base $b$ and its height $h$.

Model:

\[ A = bh \]

Symbols: $A = bh$

The area of a parallelogram is related to the area of a rectangle as you discovered in the previous Inquiry Lab.

The base of a parallelogram can be any one of its sides.
The height is the perpendicular distance from the base to the opposite side.

Parallelograms include special quadrilaterals, such as rectangles, squares, and rhombi.

Examples

1. Find the area of the parallelogram.

The base is 6 units, and the height is 8 units.

\[ A = bh \]

Area of parallelogram

\[ A = 6 \cdot 8 \]

Replace $b$ with 6 and $h$ with 8.

\[ A = 48 \]

Multiply.

The area is 48 square units or 48 units$^2$. 

Area Measurement

An area measurement can be written using abbreviations and an exponent of 2.

For example:

- square units = units$^2$
- square inches = in$^2$
- square feet = ft$^2$
- square meters = m$^2$
Area parallelograms and Triangles

Independent Practice

Find the area of each parallelogram. (Sample 1 and 2)

1. [Diagram of a parallelogram]

2. base: 6 millimeters; height: 4 millimeters

4. Find the base of a parallelogram with an area of 24 square feet and height 3 feet. (Sample 3)

5. Find the area of the parking space shown to the right. (Example 4)

6. **STEM** An architect designed three different parallelogram-shaped brick patios. Write the missing dimensions in the table.

<table>
<thead>
<tr>
<th>Patio</th>
<th>Base (ft)</th>
<th>Height (ft)</th>
<th>Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>12</td>
<td>120</td>
</tr>
<tr>
<td>2</td>
<td>11 1/2</td>
<td>10</td>
<td>115 1/2</td>
</tr>
<tr>
<td>3</td>
<td>10 1/2</td>
<td>15</td>
<td>157 1/2</td>
</tr>
</tbody>
</table>

7. The base of a building is shaped like a parallelogram. The first floor has an area of 20,000 square feet. If the base of this parallelogram is 250 feet, can its height be 70 feet? Explain.

8. **Identify Structure** Draw and label a parallelogram with a base twice as long as the height and an area less than 60 square inches. Find the area.

Robert used a piece of poster board shaped like a parallelogram to make a sign. The base of the poster board is 52 inches, and the area is 1,872 square inches. Find the height of the poster board.

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http://www.polleverywhere.com/multiple_choice_polls/BDbqvjqe7zczWzI2
How can you use the area of a parallelogram to find the area of a triangle?

Art: Yuri is making a mosaic and is cutting rectangular tiles to make triangular tiles. He wants to find the area of the triangular tiles he is cutting.

Investigation 1

Yuri starts with a rectangular piece that is 4 inches by 6 inches, similar to the size of an index card.

**Step 1** Find the area of an index card.

\[ A = \text{length} \times \text{width} \]

\[ A = \square \text{ inches} \times \square \text{ inches} \]

\[ A = \square \text{ square inches} \]

**Step 2** Use an index card. Draw a diagonal line across your index card from one corner to another. Then cut across the line. Draw the resulting figures in the space below.

**Step 3** Find the area of one of the remaining triangles. The triangle is exactly half the size of the related rectangle.

So, the area of the rectangle can be divided by 2 to find the area of one triangle.

The area is \[ \square \div 2 \], or \[ \square \] square inches.
Area parallelograms and Triangles

Investigation 2

You can also find the area of a triangle from the area of a related parallelogram.

**Step 1**
Copy the parallelogram shown on grid paper.

**Step 2**
Draw a diagonal as shown by the dashed line. Cut out the parallelogram. The area of the parallelogram is \( \square \) square units.

**Step 3**
Cut along the diagonal to form two triangles. Then find the area of one triangle. The triangle is half the size of the parallelogram. So, the area of the parallelogram can be divided by 2 to find the area of one triangle.

The area of one triangle is \( \square \div 2 \) or \( \square \) square units.

Collaborate

Work with a partner to find the area of each shaded triangle.

1. \[
\begin{array}{c}
\text{area: } \square \times \square = \\
\text{area of triangle = } \square \text{ square units}
\end{array}
\]

2. \[
\begin{array}{c}
\text{area: } \square \times \square = \\
\text{area of triangle = } \square \text{ square units}
\end{array}
\]

3. \[
\begin{array}{c}
\text{area: } \square \times \square = \\
\text{area of triangle = } \square \text{ square units}
\end{array}
\]

4. \[
\begin{array}{c}
\text{area: } \square \times \square = \\
\text{area of triangle = } \square \text{ square units}
\end{array}
\]
Area parallelograms and Triangles

**Identify Structure** Draw dotted lines to show the parallelogram or rectangle that can be used to find the area of each triangle. Then find the area of each triangle.

9. $A =$ square inches

![](image1)

10. $A =$ square yards

![](image2)

11. $A =$ square centimeters

![](image3)

12. $A =$ square feet

![](image4)

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**Analyze**

The table shows the dimensions of several parallelograms. Use the area of each parallelogram to find the missing information for each triangle. Work with a partner to complete the table. The first one is already done for you.

<table>
<thead>
<tr>
<th>Parallelogram</th>
<th>Base, $b$</th>
<th>Height, $h$</th>
<th>Area of Parallelogram (units squared)</th>
<th>Triangle created with diagonal</th>
<th>Base, $b$</th>
<th>Height, $h$</th>
<th>Area of Each Triangle (units squared)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>5</td>
<td>20</td>
<td>A</td>
<td>4</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>6</td>
<td></td>
<td>B</td>
<td>4</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>5</td>
<td></td>
<td>C</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>4</td>
<td></td>
<td>D</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>6</td>
<td>3</td>
<td></td>
<td>E</td>
<td>3</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>F</td>
<td>8</td>
<td>5</td>
<td></td>
<td>F</td>
<td>8</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>5</td>
<td>7</td>
<td></td>
<td>G</td>
<td>5</td>
<td></td>
<td>17.5</td>
</tr>
<tr>
<td>H</td>
<td>9</td>
<td>7</td>
<td></td>
<td>H</td>
<td>9</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>11</td>
<td>5</td>
<td></td>
<td>I</td>
<td>11</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
21. **Reason Inductively**  How is the area of the parallelogram related to the area of a triangle with the same base and height?

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**Reflect**

22. **Identify Repeated Reasoning**  Write a formula that relates the area $A$ of a triangle to the lengths of its base $b$ and height $h$.

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23. **Inquire**  HOW can you use the area of a parallelogram to find the area of a triangle?

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### Key Concept

**Area of a Triangle**

<table>
<thead>
<tr>
<th>Words</th>
<th>The area $A$ of a triangle is one half the product of the base $b$ and its height $h$.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbols</td>
<td>$A = \frac{1}{2}bh$ or $A = \frac{bh}{2}$</td>
</tr>
</tbody>
</table>

**Model**

A parallelogram can be formed by two congruent triangles. Since congruent triangles have the same area, the area of a triangle is one half the area of the parallelogram.

**Congruent** figures are figures that are the same shape and size.

The base of a triangle can be any one of its sides. The height is the perpendicular distance from that base to the opposite vertex.
Find the missing dimension of the triangle.
Base: 27 cm  Area: 265.5 square cm

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