Subject: Mathematics
Grade: 6th
Time: 5 Days, 45 minute periods
Tools Used:
  - Geoboards
  - Whiteboards
  - Magnetic Shapes
  - Pentominoes
  - Geometer’s Sketchpad
Objectives of Unit

- Students will be able to find the perimeter of shapes.
- Students will be able to using the perimeter formula to find the perimeter of rectangles.
- Students will be able to calculate the area of rectangles, squares, triangles and irregular polygons.
- Students will understand the formulas for perimeter and area and be able to apply them when solving problems.
- Students will be able to manipulate pentominoes to explore area and perimeter.
- Students will be able to use Geometer’s Sketchpad to create polygons of given perimeters and areas.

NCTM Standards

Content
- Number and Operations
  In this unit, students will perform operations in order to calculate perimeter and area.
- Algebra
  In this unit, students will use formulas to calculate perimeter and area.
- Geometry
  In this unit, students will be working with both regular and irregular polygons, and analyzing the shapes.
- Measurement
  In this unit, students will measure the perimeter and area of polygons.

Process
- Problem Solving
  In this unit, students will engage in inquiry to solve problems related to perimeter and area.
- Representation
  In this unit, students will construct and work with models in order to determine perimeter and area.
New York State Standards

- 6.G.2 Determine the area of triangles and quadrilaterals (squares, rectangles, rhombi, and trapezoids) and develop formulas.
- 6.G.3 Use a variety of strategies to find the area of regular and irregular polygons.
- 6.A.2 Use substitution to evaluate algebraic expressions (may include exponents of one, two and three).
- 6.PS.13 Model problems with pictures/diagrams or physical objects.
- 6.R.1 Use physical objects, drawings, charts, tables, graphs, symbols, equations, and technology as representations.
- 6.R.5 Use models to explore problem situations.

Materials and Equipment

- **Geoboards:** Each student will have a 5x5 geoboard and several rubber bands. Students will use the rubber bands on the geoboards to find shapes of certain areas and perimeters. The teacher will have an overhead geoboard to model the activities.
- **Whiteboards:** Students will use a one-foot by one-foot white board to explore problems and share answers.
- **Magnetic Shapes:** The teacher will have large magnetic shapes in the shapes of rectangles and triangles. The teacher will maneuver these shapes to demonstrate the formulas for area of shapes.
- **Pentominoes:** Each student will have a set of 12 pentominoes. Each pentomino has an area of 5 square units. Students will manipulate these to solve problems about area and perimeter.
- **Graph paper:** Students will use graph paper to assist them in finding all 12 pentomino shapes.
- **Geometer’s Sketchpad:** The class will go to the computer lab. They will do an activity using this computer program in which they will have to construct shapes of certain areas and perimeters.
- **Student Worksheets:** There will be a student worksheet to go along with each in class lesson.
### Unit Overview

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<thead>
<tr>
<th>Day</th>
<th>Materials</th>
<th>Lesson Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Geoboards, whiteboards</td>
<td>In this lesson, students will review the concept of perimeter. Students will use geoboards to find the perimeter of shapes. Students will be introduced to the formula for finding the perimeter of a rectangle given its length and width.</td>
</tr>
<tr>
<td>2</td>
<td>Magnetic shapes, Whiteboards</td>
<td>The teacher will model area formulas using magnetic shapes on the front board. During this activity, students will be introduced to the area formulas of rectangles and triangles.</td>
</tr>
<tr>
<td>3</td>
<td>Geoboards</td>
<td>Students will use geoboards to find the area of irregular shapes. Students will use the area formulas they learned the previous day in order to find the areas.</td>
</tr>
<tr>
<td>4</td>
<td>Pentominoes, graph paper, student worksheet</td>
<td>Students will be introduced to pentominoes. In this lesson, students will discover all 12 pentomino shapes using graph paper. They will use these shapes to solve problems related to area and perimeter.</td>
</tr>
<tr>
<td>5</td>
<td>Geometer’s sketchpad</td>
<td>Students will use Geometer’s Sketchpad to explore perimeter and area. In this lesson, students will be challenged to find shapes of given perimeters.</td>
</tr>
</tbody>
</table>

### Resources

**Geoboards in the Classroom** by Tom Scavo  
[http://mathforum.org/trscavo/geoboards/contents.html](http://mathforum.org/trscavo/geoboards/contents.html)

**Geometry in my World** by TEAMS Mathematics  
Day 1: Using Geoboards to explore perimeter

Objectives:
- Students will be able to create shapes using a geoboard.
- Students will be able to calculate the perimeter of shapes using the geoboards.
- Students will be able to apply and evaluate the perimeter formula.

Materials:
- Whiteboards
- Geoboards

Outline of lesson:
I will start the lesson by introducing students to the concept of perimeter by telling them I want to build a fence around my yard. I will draw an outline of my rectangular yard on the board. I will tell students the dimensions of my yard are 30 feet by 60 feet and I will label these dimensions on the board.

60 ft

Ans. 180 ft

I will have students copy this image on their whiteboards and label the appropriate sides. Students will be challenged to find the lengths of the two missing sides and label it on their whiteboards. When they have an answer, they will hold up their whiteboards. The desired reaction is that students recognize opposite sides of a rectangle are congruent, so they would label the sides 60 ft and 30 ft (opposite the given sides). I will tell students that I need to buy exactly the amount I need, not more or not less. Students will be challenged to find the amount of fencing that I need.

Students will figure the answer on their whiteboard and share it with the rest of their group. The groups will come to consensus about how much fencing we need, then share their answers with the rest of the class.

Students will be introduced to perimeter and that it measures the distance around something. Each student will be given a geoboard and some rubber bands. Using an overhead geoboard, I will model how to use these manipulatives. I will explain to students that the distance between each peg in a horizontal or vertical direction is one unit. To find the perimeter of a shape, you count the sides the rubber bands touch the pegs.

NOTE: Diagonal distances are not counted this way. We will explore that at a later date.

I will challenge students to find the perimeter of certain shapes I put on the board. They will copy the shape I make on their geoboards and then find the perimeter.

I will explain to students that another way to find the perimeter of a rectangle is to use the perimeter formula. I will go back to the original problem and have a student explain how we came up with the first answer. I am looking for students to emphasize
that they added the length twice and the width twice. I will introduce students to the formula: \( P=2l+2w \). I will substitute the values into the equation to demonstrate how it works.

On the board, I will draw a rectangle with the dimensions of 32 inches by 15 inches. Students will copy this rectangle into their notebooks and label the appropriate sides. Using the perimeter formula, students will find the perimeter of the rectangle. I will have a student come up to the whiteboard and share their answer. I will see if students had any different answers, then we will reinforce step by step how we calculate the perimeter of a rectangle using the formula.

**Ans. 94 inches**

**Homework:** Students will have a short worksheet exercising the concept of perimeter.
Homework: Perimeter

In #1-4, look at the diagram of the geoboard. Find the perimeter each shape.

1.)

Perimeter = _____ units

2.)

Perimeter = _____ units

3.)

Perimeter = _____ units

4.)

Perimeter = _____ units

5.) Use the perimeter formula to find the perimeter of the rectangle below.

6.) Use the perimeter formula to solve:
   Kyle has a poster in his room that is 18 inches by 36 inches. What is the perimeter of the poster?
**Answer Key:**

1.) Perimeter = 12 units

2.) Perimeter = 18 units

3.) Perimeter = 14 units

4.) Perimeter = 18 units

5.) \( P = 2l + 2w \)

\[
P = 2(40) + 2(16)
\]

\[
P = 80 + 32
\]

\[
P = 112 \text{ feet}
\]

6.)

```
18 inches

32 inches
```

\[ P = 2l + 2w \]

\[
P = 2(32) + 2(18)
\]

\[
P = 64 + 36
\]

\[
P = 100 \text{ inches}
\]
**Day 2: Discovering Area Formulas**

**Objectives:**
- Students will understand the derivation of area formulas.
- Students will be able to calculate the area of rectangles and triangles.

**Materials:**
- Whiteboards
- Magnetic shapes

**Outline of Lesson:**

I will tell students inside my house I need new carpet in my bedroom. My room is 10 feet by 12 feet and I will draw this on the board:

```
12ft
```

I will tell students this time that I need to buy enough square footage of carpet to cover this area: not more or less. Square footage refers to the number of 1’ by 1’ squares that can fit in a given region. I will give students whiteboards and give them the opportunity to figure it out in groups. When all students are done, we will discuss our answers.

On the board I will divide the square I drew to show the 120 squares. We will count by tens to discover the area of this region is 120. I will reinforce to students that area is measured in square units, so this answer would be 120ft². I will inquire: We know that area measures the number of square units. This figure was 12x10, which we figured out to be 120, or 12*10. Can anyone think of a formula for the area of any square or rectangle?

I will give students time to discuss it. I will call on students to share their thinking, then introduce them to the area formula for rectangles: A=b*h. I will clarify to students that since the sides of a square are equal in length, we can also express the area of a square as A= s².

I will draw a 21’x6’ rectangle on the board and ask students to find the area in their notebooks. We will go over the answer.

Ans. 126ft²

Next, I will draw a 12in x 12in square on the board. I will give students the opportunity to find the area of the square in their notebooks. We will go over the answer.

Ans. 144in²

I will put a large magnetic rectangle on the board. Next to it I will put an identical large magnetic rectangle, but this one is cut along one of the diagonals. We will discuss that these two rectangles are congruent. I will ask: What if I were to cut one triangle along the diagonal, what shapes would we have? The desired response is two
triangles. I will walk students through the process of deriving the formula for area of a triangle. If we cut a rectangle in half along the diagonal, then we have two congruent triangles. We know that the area of the rectangle (or two triangles combined) can be expressed as A=b*h. So what would the area of each triangle be? The anticipated response is \( \frac{(b*h)}{2} \) or \( \frac{1}{2}bh \). If students are not able to see this concept, we will further explore it. I will draw a triangle on the board with a base of 3’ and a height of 6’ and ask students to find the area of the shape in their notebooks. We will discuss the answer when all students have completed the problem.

Ans. 9ft\(^2\)

If time permits, we will practice some more problems using the area formula.

**Homework:** Students will have a worksheet in which they will find the area of squares, rectangles and triangles.
Name: ___________________________________

Homework: Area Formulas

For the following problems, use the appropriate formula to find the area of each shape. Don’t forget to label your answers in square units!

1.) 7 inches

2.) 12 centimeters

3.) 38 feet

4.) 10 inches

5.) 16 millimeters

6.) **CHALLENGE**

Hint: You will need two formulas to solve.
**Answer Key:**

1.) 49 in\(^2\)

2.) 108 cm\(^2\)

3.) 2774 ft\(^2\)

4.) 65 in\(^2\)

5.) 64 mm\(^2\)

6.) Area of triangle = 32 in\(^2\)

   Area of Square = 64 in\(^2\)

   Area of figure = 32 + 64 = 96 in\(^2\)
Day 3: Finding the Area of Irregular Shapes

Objectives:
- Students will be able to apply their knowledge of area to find the area of irregular shapes.
- Students will use the area formulas and the operations of subtraction or addition to find the area of irregular shapes.

Materials:
- Geoboards

Outline of Lesson:
I will use an overhead projector to project an overhead geoboard onto the board in the front of the classroom. I will have students recall that we have found the area of rectangles and triangles. I will ask two students to verbally express these formulas. Next, I will pose a question and ask, what happens if the shape is not a regular polygon? Using rubber bands, I will create an irregular polygon on the geoboard:

Ans. 5 units²

How can we find the area of this figure? At their seats, students will copy this image onto their geoboards. They will be asked to come up with an answer. While students work on this, I will be walking around questioning their methods, taking into account who found the area by adding, subtracting or another method. After several minutes, I will ask for an answer and allow several students to share their answers and the method they used to solve the problem.

I will explain to students that using the area formulas we already know, we can figure out the area of the irregular shape. One method is to break the figure into familiar pieces. Using two other rubber bands, I will separate the figure into a triangle and a square:

I will ask a student to name two shapes they see. The desired response is a square and a triangle. Students will recall these formulas once again. Using the formulas, I will have students walk me through finding the area of each shape.
Square
A= s^2
A= 2^2
A= 4 units^2

Triangle
A= \frac{1}{2} b*h
A= \frac{1}{2} (2)(1)
A= 1 unit^2

Square + Triangle = 4 + 1 = 5 units^2

I will explain to students that another way to find the area of an irregular shape is to create a square or rectangle and subtract the area of the missing pieces. Using a rubber band, I will make a rectangle that encloses the figure.

I will ask students to recall the original shape. What shapes would we have to take away from this to get back to the original shape? The desired response is two triangles (both in the upper corners of the figure). Knowing this, how can we apply subtraction to find the area of the original figure? I will have students walk me through the process, first by finding the area of the rectangle, then subtracting from it each of the two triangles.

Rectangle:
A= l*w
A= 2*3
A= 6

Triangle 1:
A= \frac{1}{2} b*h
A= \frac{1}{2} (1)(1)

Triangle 2:
A= \frac{1}{2} b*h
A= \frac{1}{2} (1)(1)

Rectangle – (Triangle 1 + Triangle 2) = 6 - (1/2 + 1/2) = 6 - 1 = 5 units^2

Students will realize the application of these two different methods.

I will put another figure onto the overhead. I will have students use either method to find the area of the irregular figure. Students will copy the shape onto their geoboards. When all students have solved the problem, I will have two students (one doing each method) come up to the front and show how they solved the problem.
Square: \[ A = s^2 \]
Triangle: \[ A = \frac{1}{2} b \times h \]
\[ A = 2^2 \]
\[ A = \frac{1}{2} (2)(3) \]
Square + Triangle = 4 + 3 = 7 units²
\[ A = 4 \text{ units}^2 \]
\[ A = \frac{1}{2} (6) \]
\[ A = 3 \text{ units}^2 \]

Method 2: Subtraction

Rectangle: \[ A = l \times w \]
Triangle: \[ A = \frac{1}{2} b \times h \]
\[ A = 4 \times 3 \]
\[ A = \frac{1}{2} (2)(3) \]
\[ A = 1 \times 2 \]
\[ A = 12 \text{ units}^2 \]
\[ A = \frac{1}{2} (6) \]
\[ A = 3 \text{ units}^2 \]

Rectangle - (Triangle + Small Rectangle) = 12 - (3 + 2) = 7 units²

If time allows, I will put another problem on the geoboard.

Homework: Students will have a worksheet about finding the area of irregular polygons.
Name: ____________________________________
Homework: Area of Irregular polygons

For #1-2, find the area of the irregular polygons by using the **addition method**. Show your work.

1.)

2.)

For #3-4, find the area of the irregular polygons using the **subtraction method**. Show your work.

3.)

4.)
Answer Key:

1.) Area of Triangle= \( \frac{bh}{2} \)  
   Area of Rectangle= \( lw \)  
   Area of Triangle = \( \frac{2*2}{2} \)  
   Area of Rectangle= 1*4  
   Area of Triangle= 2 units²  
   Area of Rectangle= 4 units²  

   Area of Triangle+ Area of Rectangle= 2+4= 6 units²

2.) Area of Square= \( s^2 \)  
   Area of Triangle= \( \frac{bh}{2} \)  
   Area of Square= \( 1^2 \)  
   Area of Triangle= \( \frac{3*3}{2} \)  
   Area of Square= 1 unit²  
   Area of Triangle= 4.5 units²  

   Area of Square+ Area of Triangle= 1+4.5= 5.5 units²

3.)

   Area of Square= \( s^2 \)  
   Area of Triangle= \( \frac{bh}{2} \)  
   Area of Square= \( 4^2 \)  
   Area of Triangle= \( \frac{4*2}{2} \)  
   Area of Square= 16 units²  
   Area of Triangle= 4 units²  

   Area of Rectangle= \( lw \)  
   Area of Rectangle= 1*2  
   Area of Rectangle= 2 units²

   Area Polygon= Area of Square- (Area of Rectangle+ Area of Triangle) = 16- (2+4)  
   = 10 units²

4.)

   Area of Rectangle= \( lw \)  
   Area of Triangle= \( \frac{bh}{2} \)  
   Area of Rectangle= \( 4*3 \)  
   Area of Triangle= \( \frac{4*2}{2} \)  
   Area of Rectangle= 12 units²  
   Area of Triangle= 4 units²

   Area of Polygon= Area of Rectangle- Area of Triangle= 12-4= 8 units²
Day 4: Using Pentominoes to Explore Area and Perimeter

Objectives:
• Students will create pentominoes using graph paper.
• Students will find the area and perimeter of shapes using pentominoes.

Materials:
• Pentominoes
• Graph paper

Outline of Lesson:
Discuss that pentominoes consist of 5 squares joined together edge to edge. Show an example of a correct and an incorrect pentomino.

Ex.

Correct

Incorrect

Students will use graph paper and colored pencils to try to figure out how many pentominoes exist. Students will assemble in small groups of 3–4 students and compare results. As a group, they will come up with an answer, write it on the back of the graph paper and hold it up when prompted to do so.

Ans. 12 pentominoes are possible

NOTE: Let students know the orientation of the shapes does not matter.
Ex.

These count as the same shape.

Give each student a set of pentominoes and introduce students to the twelve shapes of pentominoes. Tell them a way to classify and remember them is: “FLIP ‘N TUVWXYZ” and have them hold up the shape that matches the letter.

Students will be given a worksheet in which they will have to find the area and perimeter of each pentomino shape. When students are finished, we will share answers and discuss why area was preserved, but perimeter was not.
After this, students will have an activity in which they will have to find the shapes that make a larger shape. They will also find the area and perimeter of these shapes.

Homework: Students will have homework in which they will use pentominoes to make shapes and calculate the area and perimeter of these shapes.
Name: ____________________________________

In class worksheet: Area and Perimeter of Pentominoes
Note: Answers on given on the worksheet in red.

<table>
<thead>
<tr>
<th>Letter Classification</th>
<th>Shape</th>
<th>Perimeter (units)</th>
<th>Area (units$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td><img src="image" alt="F" /></td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>L</td>
<td><img src="image" alt="L" /></td>
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<tr>
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<tr>
<td><strong>W</strong></td>
<td>![Image]</td>
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<tr>
<td><strong>X</strong></td>
<td>![Image]</td>
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<tr>
<td><strong>Y</strong></td>
<td>![Image]</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td><strong>Z</strong></td>
<td>![Image]</td>
<td>12</td>
<td>5</td>
</tr>
</tbody>
</table>
In class worksheet: Pentominoes

Use pentominoes to solve each problem, then use the blank grids to copy your answer by coloring the appropriate squares. Use a different colored pencil for each piece to indicate how the pieces fit together. Use “FLIP N TUVWXYZ” to help identify the pieces.

1.) Using three pentominoes create a 3x5 rectangle.
   What is the perimeter? ______ units
   What is the area? ______ units²

2.) Find two pentominoes (other than I and L) that create the same shape as the one below. Use the blank grid to record your answer.
What is the perimeter? ______ units
What is the area? __________ units²

3.) Find three pentominoes that create shape below.

What is the perimeter? ______ units
What is the area? __________ units²
Answer Key:

Note: Answers may vary. Below is a possible solution for each problem. As long as the shapes fit and do not overlap or go over the border, the arrangement is correct.

1.)

Perimeter= 16 units
Area= 15 units²

2.)

Perimeter= 18 units
Area= 10 units²

3.)

Perimeter= 18 units
Area= 15 units²
Name: __________________________
Homework: Exploring Area and Perimeter with Pentominoes

Use pentominoes to solve each problem, then use the blank grids to copy your answer by coloring the appropriate squares. Use a different colored pencil for each piece to indicate how the pieces fit together. Use the FLIP ‘N TUVWXYZ heading on the in-class worksheet to help identify the names of the pieces.

1.) Using four pentominoes create a 4x5 rectangle.

What is the perimeter? _______ units
What is the area? ___________ units²

2.) Using 5 pieces, create a 5x5 figure.

What is the perimeter? _______ units
What is the area? ___________ units²

3.) Find three pentominoes (other than the combination of the P, V and Y pieces) that create the same shape as the one below and indicate your answer in the blank shape.
What is the perimeter? _______ units
What is the area? ___________ units²

For 4 and 5, find three pentominoes that create each shape. Find the perimeter and area of each shape.

4.)

Perimeter= _____ units
Area= _________ units²

5.)

Perimeter= _____ units
Area= _________ units²
Answer Key:
Note: Answers may vary. Below is a possible solution for each problem. As long as the shapes fit and do not overlap or go over the border, the arrangement is correct.

1.)

Perimeter= 18 units
Area= 20 units

2.)

Perimeter= 20 units
Area= 25 units

3.)

Perimeter= 18 units
Area= 15 units

4.)

Perimeter= 20 units
Area= 15 units

5.)

Perimeter= 18 units
Area= 15 units
Day 5: Geometer’s Sketchpad

Objectives:
- Students will use Geometer’s sketchpad to construct shapes of given areas and perimeters.
- Students will have an understanding of the Geometer’s Sketchpad software.

Materials:
- Computers
- Geometer’s Sketchpad

Outline of Lesson:
For this lesson, we will go to the computer lab. When we get there, each student will sit at a computer and go to The Geometer’s Sketchpad. I will project the image on my laptop so all students can see. I will go over the basics of the program and demonstrate how to construct line segments, polygons, how to find the length of a line segment, construct an interior of a polygon, find the perimeter and find the area. I will also show students how if you click and drag one of the endpoints, you can change the object and I will let them know by holding down the shift key, you can construct a vertical or horizontal line.

I will give students the opportunity to practice these concepts. As they practice, I will go around and help students out, as well as the computer teacher. I will have Geometer’s Sketchpad reference manuals available to the students.

Students will have a task in which they will construct a triangle and find its perimeter and area. Next, they will construct a quadrilateral and find its perimeter and area. These are the two tasks that are required to be completed. Students who finish or need an extra challenge will be challenged to construct a quadrilateral whose perimeter is 20 centimeters and find its area. They will then see if they can find another quadrilateral that is a different shape but has a perimeter of 20 centimeters. They will find the area of this figure as well.

Homework: There will be no homework tonight.
**Answer Key:**

1.) Construct a triangle. Then, find the perimeter and area of the triangle. The following is an example of acceptable student work.

\[ AB = 3.25 \text{ cm} \]
\[ BC = 4.59 \text{ cm} \]
\[ AC = 5.20 \text{ cm} \]

Perimeter \( \triangle BAC = 13.04 \text{ cm} \)
Area \( \triangle BAC = 7.37 \text{ cm}^2 \)

2.) Construct a quadrilateral. Then, find the area and perimeter of the quadrilateral. The following is an example of acceptable student work.

\[ DE = 3.39 \text{ cm} \]
\[ EF = 3.13 \text{ cm} \]
\[ FG = 6.46 \text{ cm} \]
\[ DG = 2.91 \text{ cm} \]

Perimeter \( DGFE = 15.89 \text{ cm} \)
Area \( DGFE = 12.19 \text{ cm}^2 \)

3.) Construct a quadrilateral with a perimeter of 20 centimeters. What is the area of this quadrilateral? The following is an example of acceptable student work.

\[ HI = 3.63 \text{ cm} \]
\[ IJ = 4.00 \text{ cm} \]
\[ JK = 7.01 \text{ cm} \]
\[ KH = 5.37 \text{ cm} \]

Perimeter \( HIJK = 20.00 \text{ cm} \)
Area \( HIJK = 21.94 \text{ cm}^2 \)
4.) Construct a different quadrilateral with a perimeter of 20 centimeters. What is the area of this quadrilateral?

The following is an example of acceptable student work.

```
LM = 4.77 cm
MN = 5.14 cm
NO = 9.32 cm
OL = 0.77 cm
```

Perimeter MNOL = 20.00 cm
Area MNOL = 6.63 cm²

5.) Why do you think it is possible for two figures to have the same perimeter, but not the same area?