3-1  Game: Name It – Claim It
Lines and Angles

Materials
- Number cube

Setup
Your teacher will divide the class into pairs.

Game Play
Use one of the four diagrams at the right to play each round of the game. At the beginning of each round, you and your partner must each claim an angle and label it with your initials.

Take turns rolling the number cube to determine an angle relationship.

1 = alternate interior 2 = alternate exterior 3 = corresponding
4 = same-side interior 5 = vertical angles 6 = linear pair

Then, initial one angle that has the given relationship to the angle you claimed. On subsequent turns, you may start from any previously initialed angles in the angle relationship. Angles may only be claimed once, so it may not always be possible to claim an angle on your turn.

Ending the Game
The round ends when all of the angles have been claimed. The player with the most angles claimed wins the round. The player who wins the most rounds wins the game.
3-2 \hspace{1em} \textbf{Activity: Playing Football} \\
\hspace{1em} \textbf{Properties of Parallel Lines}

\textbf{Materials}
- Protractor
- Ruler

A football field is marked off in a series of parallel lines. This diagram shows a play that occurred in a game between the Westside Avengers (white figure) and the Eastside Pacers (black figure). Player \#21 carries the ball. Player \#13 hopes to tackle him.

1. a. Use a protractor to measure the angles formed between the pathways of player \#21 and player \#13 and the 50-yd line.

\textit{The 50-yd line is a transversal across the players’ paths. The measures of the same-side interior angles on the west side of the 50-yd line are 65° for player \#21 and 90° for player \#13.}

b. If player \#13 can run as fast as player \#21, will he be able to overtake player \#21 beyond the 50-yd line? Explain.

\textit{Because the sum of the measures of the same-side interior angles is less than 180°, the two pathways meet beyond the 50-yd line. Since player \#13 has less distance to travel, he should be able to overtake player \#21.}

In another play, Westside \#53 carries the ball and is tackled just inches short of a first down, the team’s first attempt to gain 10 yards. The diagram below shows the path of the ball and its position, point \(B\). Point \(X\), which is 2 ft beyond the 40-yd line, shows the position the ball would have had to reach in order to make a first down. The referee is called in for a measurement. You can use geometry to prove that the ball is short of a first down.

2. Draw the segment connecting point \(B\) with point \(X\). Call it \(BX\). Draw a transversal across \(BX\) and the 40-yd line. Then use a protractor to measure either pair of alternate interior angles. Record the measurements.

\textit{Measurements may vary, however, the alternate interior angles will not be congruent.}

3. According to your measurements in Exercise 2, is \(BX\) parallel to the 40-yd line? Why or why not?

\textit{No; the alternate interior angles formed are not congruent.}

4. Summarize your findings to prove that the ball is short of a first down.

\textit{Since \(BX\) is not parallel to the 40-yd line, \(B\) is not the same distance from the 40-yd line as \(X\) is. This means that the ball is short of a first down.}
3-3 Puzzle: Cross-Number
Proving Lines Parallel

Find the value of \( x \) for which \( m \parallel n \). Write your answer in the cross-number puzzle below. Each digit and decimal point of your answer goes in its own box.

<table>
<thead>
<tr>
<th>Across</th>
<th>Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. ( (3x)^\circ ) ( (x + 7)^\circ ) ( m ) ( n )</td>
<td>( 83^\circ ) ( (16x)^\circ ) ( m ) ( n )</td>
</tr>
<tr>
<td>4. ( (8x)^\circ ) ( 111^\circ ) ( m ) ( n )</td>
<td>( 119^\circ ) ( (4x)^\circ ) ( m ) ( n )</td>
</tr>
<tr>
<td>6. ( (16x)^\circ ) ( 105^\circ ) ( m ) ( n )</td>
<td>( (2x + 5)^\circ ) ( 110^\circ ) ( m ) ( n )</td>
</tr>
<tr>
<td>8. ( 125^\circ ) ( \left(\frac{1}{2}x + 3\right)^\circ ) ( m ) ( n )</td>
<td>( (6x - 147)^\circ ) ( x^\circ ) ( m ) ( n )</td>
</tr>
</tbody>
</table>

| 1 6 | 2 4 3 . 2 5 0 |
| 3 1 4 8 . 6 2 5 5 |
| 5 5 2 2 |
| 6 . 5 6 7 2 5 6 . |
| 2 9 5 |
| 5 . |
| 8 2 4 4 |
3-4  **Game: Slide Up**  
Parallel and Perpendicular Lines

**Materials**
- Number cube
- Two coins or tokens to be used as playing pieces
- Game board

**Setup**
Play this game with a partner. Sit next to each other so that you are both facing the game board. Roll a number cube to determine who goes first. The goal is to be the first player to reach the top of the game board.

**Game Play**
1. Begin by placing your playing piece at the “Start” point at the bottom of the game board.
2. On each turn, roll the number cube to move your playing piece.
   - **Roll a 1:** Move horizontally left or right along a line segment to the next node.
   - **Roll a 2:** Move along any line segment to the next node.
   - **Roll a 3:** If you are on a perpendicular, move to an intersection point on the same perpendicular with the next line parallel to your line. If you are not on a perpendicular, then stay where you are.
   - **Roll a 4:** If you are on the vertex of a triangle, move to any other vertex of the triangle. Otherwise, stay where you are.
   - **Roll a 5:** If you are on a transversal, move toward the “Finish” point to the intersection point on the same transversal with the next line parallel to your line. If you are not on a transversal, then stay where you are.
   - **Roll a 6: Special.** Move your opponent’s game piece back one node.
3. If a playing piece lands on an opponent’s piece, move your opponent’s piece back to “Start.”

**Ending the Game**
The game ends when one player reaches the “Finish” point.

**Variations**
- When a player’s game piece reaches the “Finish” point, he or she scores 1 point and moves his or her game piece to the “Start” point. The other players do not move their pieces to the “Start” point and the game continues. The player who scores the most points wins.
- Write your own rules for moving around the game board.
3-4

Game: Slide Up Game Board
Parallel and Perpendicular Lines

Segments that appear to be parallel are parallel. Segments that appear to be perpendicular are perpendicular.
Activity 1 suggests one of the most important ideas of Euclidean geometry.

Activity 1

- Draw and cut out a large triangle.
- Number the angles and tear them off.
- Place the three angles adjacent to each other to form one angle, as shown at the right.

1. What kind of angle is formed by the three smaller angles? What is its measure? **straight angle; 180°**
2. Make a conjecture about the sum of the measures of the angles of a triangle. **The sum of the measures is 180°.**

Activity 2

- Fold a sheet of paper in half three times. Draw a **scalene triangle** (no two sides congruent) on the folded paper. Carefully cut out the triangle. This will give you eight triangles that are all the same size and shape.
- Number the respective angles of each triangle 1, 2, and 3. (Use the same number on the corresponding angles from one triangle to the next.)

3. Mark a point **P** in the middle of a blank sheet of paper. How many of your triangles do you think you can fit perfectly about point **P** without gaps or overlaps? **6**
4. What conjecture are you making about the sum of the measures of the angles about a point? **The sum is 360°.**

Exercises

5. Use the triangles from Activity 2. Based on your conjectures above, what combination of angles 1, 2, and 3 can you place at a point **P** to guarantee a perfect fit of triangles about **P**? **The sum of the angles of a triangle is 180°. By using 2 of each angle, the sum will be 360°.**
6. There are several ways to arrange the set of six angles 1, 1, 2, 2, 3, 3 to make a perfect fit about **P**. Make three different listings of the numbers 1, 1, 2, 2, 3, 3 around a point. Arrange your triangles about **P** to match your lists. Is any arrangement more appealing than the others? What happens if you turn over some of the triangles? **Check students’ work.**
7. Follow the steps of Activity 1 using a **quadrilateral** (four-sided figure). Make a conjecture about the sum of the measures of the angles of a quadrilateral. **The sum is 360°.**
8. If you fit the angles of a quadrilateral about a point **P** without gaps or overlaps, what do you think you would discover? Justify your response. **The angles would fit perfectly since their measures have a sum of 360°.**
3-6 Puzzle: House Construction
Constructing Parallel and Perpendicular Lines

You are a builder about to build a home. Instead of giving you a drawing, the architect gives you the segments and angle at the right and the descriptions below. Using only a compass and straightedge, follow the architect’s directions to make a two-dimensional construction of the house. Show all of the arcs and lines you use for each construction.

1. The width of the house is $2AB + CD$.
2. The walls are perpendicular to the base and have a height of $AB$.
3. The measure of the angle from the horizontal ceiling on top of the walls to the roof is $\frac{3}{2} m \angle E$.
4. The door is in the middle of the house and has a width of $CD$ and a height of $\frac{3}{4} AB$.
5. The tops of the windows are level with the top of the door. There are windows centered between the door and each side of the house. The windows are square with sides measuring $\frac{1}{2} AB$.

Construction arcs and lines may vary. Sample:
3-7 **Activity: Exploring Point-Slope Form**

Equations of Lines in the Coordinate Plane

While *slope-intercept* form is convenient for graphing linear equations by hand, it is often easier to work with linear equations in *point-slope* form. You have learned that a line that passes through the point \((h, k)\) with slope \(m\) has an equation that can be written in point-slope form as

\[ y - k = m(x - h). \]

To enter this into your calculator, all you need to do is move \(k\) to the other side:

\[ y = m(x - h) + k \]

**Investigate**

1. Find the equation of the line in point-slope form that goes through \((2, 1)\) and has slope 3. Enter the equation in the calculator and use the “square” window shown at right.

\[ y - 1 = 3(x - 2) \]

2. To highlight the point \((2, 1)\), store the coordinates in \(L1\) and \(L2\) as shown, using the curly brackets.

*Check students’ work.*

3. Next, press \(2^{nd}\) stat plot and \(\rightarrow\). Set up Plot 1 as shown in the screen below. Press \(\rightarrow\) to see the line with slope 3 passing through \((2,1)\).

*Check students’ work.*
4. Now graph several lines through (2, 1) having different slopes. Store the slopes \{0, \pm 1, \pm 2\} in L3 and use L3 as the slope of the line, as shown below. (Notice the use of the multiplication sign in the second screen. A list followed directly by a parenthesis has a special meaning and is not interpreted by the graphing calculator as multiplication.) Check students’ work.

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Exercises

1. Produce a graph of a line through the point (−5, 6) with slope −2. Change WINDOW variables appropriately.

2. Produce a graph of four different lines through (−5, 6).

3. Produce a graph of two perpendicular lines intersecting at (4, 9).

4. Produce a graph of four different lines with x-intercept 3.
Cut out the squares below. Arrange squares 1−9 to form a 3-by-3 square so that the equations touching each other at the edges are the equations of parallel lines. Then, arrange squares 10−18 to form a 3-by-3 square so that the equations touching each other at the edges are the equations of perpendicular lines.

<p>| | | | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>(28 - 9x = 4y)</td>
<td>(y = \frac{2}{3}x + 2)</td>
<td>(y = \frac{2}{3}x + 8)</td>
<td>(y = \frac{1}{4}x + 2)</td>
</tr>
<tr>
<td>(x = 6)</td>
<td>(y = \frac{2}{3}x + 2)</td>
<td>(y = \frac{1}{4}x + 2)</td>
<td>(y = \frac{1}{4}x + 2)</td>
</tr>
<tr>
<td>(0 = 3 - \lambda)</td>
<td>(0 = 3 - \lambda)</td>
<td>(y = -\frac{1}{3}x + 4)</td>
<td>(y = \frac{5}{3}x + 8)</td>
</tr>
<tr>
<td>(6x - 4y = 20)</td>
<td>(y = 6x - \frac{1}{3})</td>
<td>(y = \frac{1}{4}x - \frac{2}{3})</td>
<td>(y = -\frac{6}{5}x + 3)</td>
</tr>
<tr>
<td>(y = \frac{3}{4}x + \frac{5}{2})</td>
<td>(y = \frac{1}{4}x - \frac{2}{3})</td>
<td>(y = \frac{1}{4}x - \frac{2}{3})</td>
<td>(y = \frac{6}{5}x + 1)</td>
</tr>
<tr>
<td>(5 - \frac{3}{2}x = x)</td>
<td>(5 - \frac{3}{2}x = x)</td>
<td>(5 - \frac{3}{2}x = x)</td>
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<td>(y = \frac{2}{3}x + 4)</td>
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