**Topic C**

**Drawing Figures in the Coordinate Plane**

5.G.1, 5.G.2

| Focus Standard: | 5.G.1 | Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plan located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate).

| 5.G.2 | Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

| Instructional Days: | 5 |
| Coherence -Links from: | G4–M4 | Angle Measure and Plane Figures |
| | G4–M5 | Fraction Equivalence, Ordering, and Operations |
| -Links to: | G6–M4 | Expressions and Equations |

In Topic C, students draw figures in the coordinate plane by plotting points to create parallel, perpendicular, and intersecting lines. They reason about what points are needed to produce such lines and angles, and investigate the resultant points and their relationships. In preparation for Topic D, students recall Grade 4 concepts such as angles on a line, angles at a point, and vertical angles—all produced by plotting points and drawing figures on the coordinate plane (5.G.1). To conclude the topic, students draw symmetric figures using both angle size and distance from a given line of symmetry (5.G.2).
## A Teaching Sequence Towards Mastery of Drawing Figures in the Coordinate Plane

| Objective 1 | Construct parallel line segments on a rectangular grid. (Lesson 13) |
|Objective 2 | Construct parallel line segments, and analyze relationships of the coordinate pairs. (Lesson 14) |
|Objective 3 | Construct perpendicular line segments on a rectangular grid. (Lesson 15) |
|Objective 4 | Construct perpendicular line segments, and analyze relationships of the coordinate pairs. (Lesson 16) |
|Objective 5 | Draw symmetric figures using distance and angle measure from the line of symmetry. (Lesson 17) |
Lesson 13

Objective: Construct parallel line segments on a rectangular grid.

Suggested Lesson Structure

- Fluency Practice (12 minutes)
- Concept Development (38 minutes)
- Student Debrief (10 minutes)
- Total Time (60 minutes)

Fluency Practice (12 minutes)

- Multiply 5.NBT.5 (5 minutes)
- Draw Angles 4.G.6 (7 minutes)

Multiply (5 minutes)

Materials: (S) Personal white boards

Note: This drill reviews year-long fluency standards.

T: Solve $43 \times 23$ using the standard algorithm.
S: (Write $43 \times 23 = 989$ using the standard algorithm.)

Continue the process for $543 \times 23$, $49 \times 32$, $249 \times 32$, and $954 \times 25$.

Draw Angles (7 minutes)

Materials: (S) Blank paper, ruler, protractor

Note: This fluency activity reviews Grade 4 concepts and prepares students for today’s lesson.

T: Use your ruler to draw a 4-inch horizontal line on your paper.
T: Plot four points at random on the line.
T: Use each point as a vertex. Above the line, draw and label 30° angles that open to the right.

Repeat with 60° and 45° angles as time permits. Students should notice each set of lines is parallel.
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Concept Development (38 minutes)

Materials: (T) Triangle templates in various sizes (made from rectangle template) (S) Straightedge, rectangle template (used to make triangle templates), recording sheet, scissors, unlined paper

Note: An Application Problem is not included in this lesson in order to provide adequate time for the Concept Development.

Problem 1: Construct parallel lines using a triangle template and straightedge.

Note: Demonstrate and give work time to the level your students need throughout this process.

T: (Distribute 1 rectangle template and unlined paper to each student.)

T: Cut out the 5 unit by 2 unit rectangle.

T: (Allow students time to cut.) Position your rectangle on your paper so that the horizontal side is 5 units.

T: With your straightedge, draw the diagonal from the lower left to the upper right vertex.

T: Cut along the diagonal.

T: Put one of the right triangles away. Tell your neighbor some things that you know about it.

S: One angle is a right angle and measures 90 degrees. \(\rightarrow\) One side is 2 units long and the other side is 5 units. \(\rightarrow\) The angles that aren’t 90 degrees are acute.

T: Place your triangle on your paper so that the horizontal side is 5 units and the 90-degree angle is to the right.

T: Label the right angle and name its vertex \(R\).

T: Name the vertex of the angle at the top of the triangle as \(T\) and the vertex of the angle at left as \(S\).

T: Place your straightedge horizontally across your paper, then place the base of the triangle along the straightedge. Trace a line across \(ST\).

T: Slide triangle \(RST\) to the right, about an inch, along your straightedge, without moving the straightedge. Trace a second line across \(ST\).

T: Remove the triangle and straightedge from your paper. What do you notice about the two line segments you’ve drawn? Turn and talk.

S: We traced the same segment twice, so they’re the same length. \(\rightarrow\) They are parallel because angle \(S\) is the same and comes out of the same line.

T: Let’s try it again, but this time we’ll arrange our straightedge so that it’s oriented vertically on our paper.
Repeat the same construction along a vertical straightedge, moving the triangle down about an inch before tracing the parallel segment. Then, have students work with a partner to cut out the remaining rectangles and bisect them on the diagonal to create a variety of right triangles.

T: Continue to construct parallel segments using a variety of angle templates. Place your straightedge in a variety of ways on your paper. Share your work with a neighbor as you work. Think about how the angles of your triangles change as the sides change.

Problem 2: Identify parallel segments on grid paper.

T: (Distribute parallel lines recording sheet to students. Display image of segments $AB$ and $CD$ on board.) Put your finger on line segment $AB$.

S: (Put finger on line segment.)

T: Using the gridlines, visualize a right triangle that has $AB$ as its longer side. Tell your neighbor what you see.

S: The triangle is here. It has a height of 2 units and a base of 3 units. $\rightarrow$ The right angle would be at the bottom and across from segment $AB$. $\rightarrow$ I see a triangle that is above $AB$. The right angle is on the top right across from $AB$.

T: (Shade triangle.) The triangle has a height of 2 units and a base of 3 units. (Mark right angle with right angle symbol.) Shade the triangle on your paper.

T: Now look at segment $CD$. Shade a right triangle that has $CD$ as its longer side.

T: What do you notice about the two triangles that were used to construct each segment? Turn and talk.

S: They’re the exact same triangle. $\rightarrow$ For $CD$ the triangle just moved over to the right. $\rightarrow$ The triangles have the same side lengths and the angles look like they are the same size too.

T: This is the same as when we slid our triangles along the straightedge. Now the triangle is sliding along the grid lines. (Drag finger along the grid line to show the movement of the triangle.) Can we say then, that segment $AB$ is parallel to $CD$? Why or why not?

S: Yes, they’re parallel because they intersect the grid line at the same angle.

Repeat the process with $EF$ and $GH$.

T: If $EF$ was drawn first, how was the triangle moved before $GH$ was constructed? Turn and talk.

S: The triangle moved to the right and then down. $\rightarrow$ I can see that the triangle moved 1 grid square down and 1 grid square to the right. So that means that the segment’s endpoints moved the same way.
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Construct parallel line segments on a rectangular grid.

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T: (Display segments $IJ$ and $KL$ on board.) Look at segments $IJ$ and $KL$. Shade the right triangles that have these segments as one of their longer sides.

T: Are the segments parallel? Turn and talk.

S: No. The triangle for $IJ$ is taller. $KL$ has a height of 2 and $IJ$ has a height of 3. I can see that if we extend each segment, they intersect.

T: (Model extension of segments and their intersection.) As I extend these segments, are they parallel?

S: No, they intersect so they can’t be parallel.

T: Let’s consider something else about these segments. Imagine that we slid the longer segment over 1 unit to the right. Would the segments line up perfectly? Why or why not?

S: I can see the little one inside the big one. They are at different angles. They won’t line up. The acute angles in the triangles are different sizes so they don’t have the same steepness which means they won’t line up. One segment is over 1 up 2 and the other one is over 1 up 4. That makes the angles in the triangles different sizes.

T: (Display segments $MN$ and $OP$ on board.) Look at segments $MN$ and $OP$. Are they parallel segments?

S: They look like they’re parallel, but the triangle that includes $MN$ has a height of 2 units and a base of 2 units, and the triangle for $OP$ has a height of 4 units and a base of 4 units. I extended segment $MN$, and now it’s the same length as $OP$, and they are parallel.

T: The triangle that I can see for $MN$ has a height of 2 units and a base of 2 units. (Shade triangle.) It looks like $OP$ is the side of a triangle with a height and base of 4 units.

T: Look inside the larger triangle. Do you see two triangles like the one related to $MN$? (Point out the two triangles.)

S: (Shade two separate triangles beneath $MN$.) I can also see two triangles, each with heights and bases of 2 units, just like the triangle that includes $MN$.

T: What do you think now? Are the segments parallel?

S: I see it now, they are parallel. $OP$ is just longer. We could have also just extended $MN$ to make it longer, and then it could be part of a triangle with a height and base of 4 units.

Problem 3: Construct parallel segments on grid paper.

T: (Display image of segment $QR$ on board.) Tell your neighbor about the triangle that you see that has segment $QR$ as a side.

S: (Discuss triangle.)

T: Draw a segment parallel to $QR$ that goes through point $S$. Tell your neighbor what you did.
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S: I drew a triangle that’s the same as the one that includes \( \overline{QR} \) with a height of 2 units and a base of 1 unit directly below point \( S \). Then, I put a point at the right end of the base, and connected it to point \( S \). \( \rightarrow \) I went down 2 units from \( Q \) and then right 1 unit to point \( R \). So I went down 2 units from \( S \) and right 1 unit and made a point to connect to \( S \).

T: Watch me. I visualized a triangle with a height of 2 and a base of 1 beneath segment \( \overline{QR} \). (Demonstrate.) If I visualize the same triangle beneath point \( S \), I can find a point to connect with point \( S \), to make a parallel segment. (Demonstrate.)

T: Draw parallel segments for the other two examples on your paper. Share your work with a neighbor. (Allow students time to work.)

T: (Display image of line \( \ell \) on board.) Look at line \( \ell \). Think about the triangle that you are visualizing for line \( \ell \). (Give students time to think.) Tell your neighbor about what you visualized.

S: I can see a triangle with a height to 3 and a base of 12. \( \rightarrow \) I see a triangle with a height of 2 and a base of 8. \( \rightarrow \) I can see a bunch of triangles each with a height of 1 and a base of 4.

T: I heard that you saw several different triangles for line \( \ell \). Some of you saw a large triangle with a height of 3 units and a base of 12 units. (Use finger to show on board.) Others saw a series of smaller triangles with a height of 1 unit and a base of 4 units. Let’s construct a line that is parallel to line \( \ell \). Draw a point on the grid somewhere above line \( \ell \). (Model on board.)

S: (Draw point.)

T: Now, plot a second point that creates the side of the triangle you visualized. For example, some of you visualized a triangle with a height of 2 units and a base of 8 units, so you’ll move 2 units down and 8 units to the right, then plot a point. (Model on board.)

S: (Plot point.)

T: Use your straightedge to draw a line parallel to line \( \ell \) through the two points you’ve plotted. (Allow students time to draw line.)

T: Do the same thing again, but this time, construct your line below line \( \ell \).

Note: The triangle templates the students created today will be used in future lessons. It may be helpful to keep them in individually labeled plastic bag.

Problem Set (10 minutes)

Students should do their personal best to complete the Problem Set within the allotted 10 minutes. For some classes, it may be appropriate to modify the assignment by specifying which problems they work on first. Some problems do not specify a method for solving. Students solve these problems using the RDW approach used for Application Problems.

Student Debrief (10 minutes)

Lesson Objective: Construct parallel line segments on a rectangular grid.

The Student Debrief is intended to invite reflection and active processing of the total lesson experience.
Invite students to review their solutions for the Problem Set. They should check work by comparing answers with a partner before going over answers as a class. Look for misconceptions or misunderstandings that can be addressed in the Debrief. Guide students in a conversation to debrief the Problem Set and process the lesson.

You may choose to use any combination of the questions below to lead the discussion.

- In Problem 1, share your parallel lines with a partner. Explain how you drew the lines.
- Compare and share your solution for Problem 2 with a partner. Explain how you know the lines are parallel. For the segments that were not circled, how did you determine that they were not parallel?
- Compare and check your answers for Problem 3 with a partner. Do you have the same answer? (It is possible that two students may create different segments that lie on the same parallel line, perhaps on Problem 3(f). Be sure to point out that while the segments aren’t the same, they do lie on the same line.)
- On Problem 4, did you draw the same lines as your neighbor? If your answers are different, are you both correct? How is that possible?
- Go back to $EF$ and $GH$. We draw $EF$. We slide down 1 grid square and draw the same segment. That new segment is parallel to $EF$. Then, slide over 1 grid square and draw $GH$. $GH$ is parallel to our new segment. $EF$ is parallel to the new segment and $GH$ is parallel to the new segment. Then what do we know about $EF$ and $GH$?
- How does drawing these parallel segments relate to our fluency activity with angles?

**Exit Ticket (3 minutes)**

After the Student Debrief, instruct students to complete the Exit Ticket. A review of their work will help you assess the students’ understanding of the concepts that were presented in the lesson today and plan more effectively for future lessons. You may read the questions aloud to the students.
1. Use a right angle template and straightedge to draw at least four sets of parallel lines in the space below.

2. Circle the segments that are parallel.
3. Use your straightedge to draw a segment parallel to each segment through the given point.

   a.  
   b.  
   c.  
   d.  
   e.  
   f.  

4. Draw 2 different lines parallel to line $b$.  

   $b$
Lesson 13 Exit Ticket

1. Use your straightedge to draw a segment parallel to each segment through the given point.

   a. 
   b. 
   c. 

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Name ___________________________ Date ________________
Lesson 13 Homework

Name ________________________________ Date ______________

1. Use your right angle template and straightedge to draw at least three sets of parallel lines in the space below.

2. Circle the segments that are parallel.
3. Use your straightedge to draw a segment parallel to each segment through the given point.

4. Draw 2 different lines parallel to line $\ell$. 

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| Lesson 13: Construct parallel line segments on a rectangular grid. |
| Date: 1/31/14 |
Lesson 13: Construct parallel line segments on a rectangular grid.

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Lesson 13
Construct parallel line segments on a rectangular grid.
1/31/14

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Lesson 13: Construct parallel line segments on a rectangular grid.

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Lesson 14

Objective: Construct parallel line segments, and analyze relationships of the coordinate pairs.

Suggested Lesson Structure

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Application Problem (7 minutes)

Drew’s fish tank measures 32 cm by 22 cm by 26 cm. He pours 20 liters of water into it, and some water overflows the tank. Find the volume of water, in milliliters, that overflows.

Note: Today’s Application Problem reviews volume concepts from G5–Module 5.

Fluency Practice (14 minutes)

- Multiply Multi-Digit Whole Numbers 5.NBT.5 (4 minutes)
- Multiply and Divide Decimals 5.NBT.7 (3 minutes)
- Draw Angles 4.G.1 (7 minutes)

Multiply Multi-Digit Whole Numbers (4 minutes)

Materials: (S) Personal white boards

Note: This drill reviews year-long fluency standards.

T: Solve 45 \times 25 using the standard algorithm.
S: (Write 45 \times 25 = 1,125 using the standard algorithm.)

Continue process for 345 \times 25, 59 \times 23, 149 \times 23, and 756 \times 43.
Multiply and Divide Decimals (3 minutes)

Materials: (S) Personal white boards

Note: This fluency activity reviews G5–Module 2 concepts.

T: (Write $4 \times 2 = \_\_\_\_\_\_\_\_\_\_\_\_)$ What’s $4 \times 2$?
S: 8.
T: (Write $4 \times 2 = 8$. Beneath it, write $0.4 \times 2 = \_\_\_\_\_\_\_\_\_\_\_\_\_)$ What’s $0.4 \times 2$?
S: $0.4 \times 2 = 0.8$.
T: (Write $0.4 \times 2 = 0.8$. Beneath it, write $0.04 \times 2 = \_\_\_\_\_\_\_\_\_\_\_\_\_)$ Write the number sentence.
S: (Write $0.04 \times 2 = 0.08$.)
T: (Write $800 \div 10 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)$ What’s $800 \div 10$?
S: 80.
T: (Write $800 \div 10 = 80$. Beneath it, write $80 \div 10 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)$ What’s $80 \div 10$?
S: 8.
T: (Write $80 \div 10 = 8$. Beneath it, write $8 \div 10 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)$ Write the number sentence.
S: (Write $8 \div 10 = 0.8$.)
T: (Write $8 \div 10 = 0.8$. Beneath it, write $8 \div 20 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)$ Write the number sentence.
S: (Write $8 \div 20 = 0.4$.)

Continue the process for the following possible suggestions: $8 \div 40, 15 \div 5, 15 \div 50, 2.5 \div 10, 2.5 \div 50, 0.12 \div 3$, and $0.12 \div 30$.

Draw Angles (7 minutes)

Materials: (S) Blank paper, ruler, protractor

Note: This fluency activity informally prepares students for today’s lesson. Provide students time to work following each step.

T: Use your ruler to draw two parallel 4-inch horizontal lines on your paper.

T: Plot 5 points, one at each inch, including 0 inches.

T: Use the points at 0 and 2 inches on the upper line as the vertices of two angles with the same measure.

T: Use the points at 1 inch and 3 inches on the lower line as the vertices of two angles with the same measure as those on the upper line.
Repeat as time allows. Take note as to whether the students observe which lines are parallel as they attempt to explain why.

**Concept Development (29 minutes)**

**Materials:** (T) Right angle template $RST'$ (with a base of 5 units and a height of 2 units) (S) Personal white board, coordinate plane template, straightedge, right angle template $RST'$ (created in G5–M6–Lesson 13)

**Problem 1:** Slide right triangle template parallel to the axes along coordinate plane to create parallel segments.

**Note:** Demonstrate and give work time to the level your students need throughout this process.

**T:** (Distribute coordinate plane template to students and display coordinate plane on board.) Plot points $A$ and $B$ at the following locations. (Display $A$: (2, 3) and $B$: (7, 5) on the board.)

**T:** Draw $\overline{AB}$.

**T:** Turn and tell your neighbor about a right triangle that you can see that has $\overline{AB}$ as its longest side. Use the grid lines to help you.

**S:** I see one with a base of 5 units and height of 2 units. $\Rightarrow$ It has two acute angles. $\Rightarrow$ The bottom left angle is less than the top right one because the triangle is going across more than it is going up.

**T:** Find triangle $RST'$ that you cut out during yesterday’s lesson. Remember that the letters name the vertices of the angles in this triangle.

**T:** Tell your neighbor how you can use triangle $RST'$ to draw a segment parallel to $\overline{AB}$.

**S:** It’s just like we did yesterday. I can slide triangle $RST'$ to the right or to the left and trace the long side of the triangle. $\Rightarrow$ I can move the triangle along the grid lines like yesterday. Up, down, left, right, or a combination of horizontal and vertical movements are ok as long as I keep the horizontal side parallel to the gridlines. $\Rightarrow$ It’s like we did in Fluency Practice: Because $\angle S$ is the same as $\angle A$ coming off the same base line, the lines will be parallel.

**T:** Yes, we can slide triangle $RST'$ along the grid lines, in a variety of directions, and then trace side $\overline{ST}$ to make parallel segments. (Demonstrate.)

**T:** Place your triangle back where it would be if you were first drawing $\overline{AB}$. (Show right triangle template $RST'$ on coordinate plane, just beneath $\overline{AB}$.)

**T:** Slide triangle $RST'$ to the right, one full grid square. (Model on the board.) Is side $\overline{ST}$ parallel to segment $\overline{AB}$?

**S:** Yes.

**T:** What coordinates does the vertex of $\angle S$ touch now?

**S:** (3, 3).

**T:** The vertex of $\angle T$?
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Construct parallel line segments, and analyze relationships of the coordinate pairs.

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S: (8, 5).
T: Tell your neighbor how the x-coordinates of the endpoints changed when I slid the triangle one unit to the right.
S: They went from 2 to 3, and 7 to 8. → Both x-coordinates are 1 more than they were.
T: Do the y-coordinates of the endpoints change?
S: No.
T: As triangle $RST$ slides one unit to the right, the x-coordinates of the vertices are increased by 1.

(Move the triangle template back to original position.) Tell a neighbor how the x-coordinates would change if the triangle were slid along the gridlines 2 units to the left. (Slide the triangle template to the left.)

S: Both x-coordinates would be 2 less. → It’s subtracting 2 from the x-coordinates of the vertices.

Repeat the process, moving 3 to the right and 3 to the left, asking students to analyze the change in the x-coordinate.

T: Position your triangle back at its original location. (Demonstrate.)
T: Watch as I slide the triangle up, along the grid lines two units. Is $ST$ parallel to $AB$? How do you know?
S: Yes. You kept the base parallel to the x-axis while you were sliding it up. → You slid it like there was a ruler on the left which is perpendicular to the x-axis, and you kept the triangle up against it the whole time.
T: What coordinates does the vertex of $\angle S$ touch?
S: (2, 5).
T: The vertex of $\angle T$?
S: (7, 7).
T: Tell your neighbor how the y-coordinates of the vertices changed when I slid the triangle along the gridlines 2 units up.

(Allow students time to share.)
T: Did the x-coordinates of the vertices change?
S: No.
T: As triangle $RST$ slides 2 units up parallel to the y-axis, the y-coordinates are increased by 2. (Move the triangle template back to the original position.)

Repeat the process, sliding the triangle both up and down and analyzing the change in the y coordinates.

Problem 2: Slide right triangle template two directions along coordinate plane to create parallel segments.

T: Return triangle $RST$ to its original location. Slide your triangle 2 units to the right and one unit down. Tell your neighbor how the coordinates of the vertices of $\angle S'$ and $\angle T'$ have changed.
T: Trace $ST$ on your plane. (Demonstrate.) Label the endpoints of your segment, as $S$ and $T$.
T: Remove your triangle. Are $AB$ and $ST$ parallel? How do you
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know? Turn and talk.

S: They don’t form a right angle, so they’re not perpendicular. → They never touch, so they’re parallel.
→ This is like yesterday. When we slide the triangle down, we can think about a parallel imaginary segment. Then, when we slide it over, we find a third segment that’s parallel to the imaginary one and then we draw it.

T: \( AB \) and \( ST \) are parallel to each other because they are both parallel to the imaginary segment we found when we first slid the triangle down. We can also think about the angles in the triangles. \( \angle A \) and \( \angle S \) are the same measure because they were drawn from parallel baselines. So we can write, \( AB \parallel ST \). (Write \( AB \parallel ST \) on the board.) Show me this statement on your personal board.

T: Record the coordinates of points \( S \) and \( T \).

T: Compare the coordinates of points \( A \) and \( B \) to the coordinates of points \( S \) and \( T \). Tell your neighbor why each \( x \)-coordinate in points \( S \) and \( T \) are 2 more than the \( x \)-coordinates in points \( A \) and \( B \).

S: We shifted the triangle to the right, so the \( x \)-coordinate increased. → We slid the triangle over 2 units along the gridlines, so both \( x \)-coordinates are 2 more.

T: Tell your neighbor why the \( y \)-coordinates are 1 less.

S: We shifted the triangle to down, so the \( y \)-coordinate decreased. → We slid the triangle 1 grid squares down, so both \( y \)-coordinates are 1 less.

Problem 2: Identify coordinate pairs that create parallel lines.

T: (Display image of the second coordinate plane.) On the coordinate plane at the bottom of your page, plot the following points. (Write \( C(1 \frac{1}{2}, 2 \frac{1}{2}) \) and \( D(3, 2) \) on the board.)

T: Use your straightedge to draw \( CD \).

T: Tell your neighbor about a right triangle that has \( CD \) as its long side and its right angle’s vertex at \( (1 \frac{1}{2}, 2) \).

S: I see a triangle with a height of 1 unit and a length of 3 units. → The right angle is to the left, 1 unit beneath point \( C \).

T: Focus for a moment on the vertex of the triangle that is at point \( C \). Now, visualize that triangle moving 2 grid units to the left. Tell your neighbor the location of that vertex now.

S: \( (\frac{1}{2}, 2 \frac{1}{2}) \).

T: Plot a point, \( E \), at that location.

S: (Plot \( E \).)

T: Plot another point, \( F \), on the plane, that when connected to \( E \) will create a segment parallel to \( CD \). Tell your neighbor how you’ll identify the location of point \( F \).

S: It looks like point \( C \) slid 2 units to the left, so I can slide point \( D \) 2 units to the left also. → If I think of the triangle I saw with \( CD \), I can go down 1 unit from \( E \) and then right 3 units. That will be point \( F \).
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The x-coordinate of E is 1 less than C, so I can subtract 1 from D to find the x-coordinate of F.

T: Name the location of point F.
S: (2, 2).
T: Plot point F, then draw $\overline{EF}$ on your plane.
T: Imagine the lines that contain $\overline{CD}$ and $\overline{EF}$. If the part of these lines that we’ve drawn here are parallel to each other, we can say that the lines that contain them are also parallel. Write a statement naming the relationship between these two lines. (Draw arrows to show lines.)
S: Lines $\overline{CD}$ and $\overline{EF}$ are parallel. → (Write $\overline{CD} \parallel \overline{EF}$.)
T: Plot a point, G, at $(3\frac{1}{2}, 2\frac{1}{2})$.
S: (Plot point.)
T: Compare the coordinates of point C to point G. Tell your neighbor how are they different.
S: (Discuss differences.)
T: Name the location of a point, H, that when connected to G, would create a segment parallel to line $\overline{CD}$.
S: (2, 3). → (5, 2). → ($\frac{5}{2}, 3\frac{1}{2}$).
T: Tell your neighbor how you identified the location of point H.
S: (Discuss with neighbor.)
T: Draw $\overline{GH}$ and write a statement about the relationship between these lines.

Problem Set (10 minutes)

Students should do their personal best to complete the Problem Set within the allotted 10 minutes. For some classes, it may be appropriate to modify the assignment by specifying which problems they work on first. Some problems do not specify a method for solving. Students solve these problems using the RDW approach used for Application Problems.

Student Debrief (10 minutes)

Lesson Objective: Construct parallel line segments, and analyze relationships of the coordinate pairs.

The Student Debrief is intended to invite reflection and active processing of the total lesson experience.
Invite students to review their solutions for the Problem Set. They should check work by comparing answers with a partner before going over answers as a class. Look for misconceptions or misunderstandings that can be addressed in the Debrief. Guide students in a conversation to debrief the Problem Set and process the lesson.

You may choose to use any combination of the questions below to lead the discussion.

- Tell your neighbor about the triangle you visualized in Problem 1. Do the same for Problem 2.
- Show your coordinate pairs from Problem 1(g) to your neighbor. Can they identify how you manipulated the coordinates?
- Share the coordinate pairs you found for $L$ and $M$ in Problem 2(c). Explain how a triangle template could have been used to construct $LM$ parallel to $EF$. How many different ways would there be to slide the triangle template and get the same line?
- Explain your thought process as you identified the location of point $H$ in Problem 2(f).
- Will any movement of a triangle on a grid produce parallel lines? Why or why not? What must we remember when we are using a triangle or set square to draw parallel lines either on a grid or off? (Students should mention the importance of keeping the movements parallel to one axis while perpendicular to the other.)

**Exit Ticket (3 minutes)**

After the Student Debrief, instruct students to complete the Exit Ticket. A review of their work will help you assess the students’ understanding of the concepts that were presented in the lesson today and plan more effectively for future lessons. You may read the questions aloud to the students.
1. Use the coordinate plane below to complete the following tasks.

   a. Identify the locations of $P$ and $R$. 
      $P$: (____, ____)
      $R$: (____, ____)

   b. Draw $\overrightarrow{PR}$.

   c. Plot the following coordinate pairs on the plane.
      $S$: (6, 7)  $T$: (11, 9)

   d. Draw $\overrightarrow{ST}$.

   e. Circle the relationship between $\overrightarrow{PR}$ and $\overrightarrow{ST}$. 
      $\overrightarrow{PR} \perp \overrightarrow{ST}$  
      $\overrightarrow{PR} \parallel \overrightarrow{ST}$

   f. Give the coordinates of a pair of points, $U$ and $V$, such that $\overrightarrow{UV} \parallel \overrightarrow{PR}$.
      $U$: (____, ____)
      $V$: (____, ____)

   g. Draw $\overrightarrow{UV}$. 
2. Use the coordinate plane below to complete the following tasks.

a. Identify the locations of $E$ and $F$.  \[ E: (____, ____), \quad F: (____, ____). \]

b. Draw $\overline{EF}$.

c. Generate coordinate pairs for $L$ and $M$, such that $\overline{EF} \parallel \overline{LM}$.

\[ L: (____, ____), \quad M: (____, ____). \]

d. Draw $\overline{LM}$.

e. Explain the pattern you made use of when generating coordinate pairs for $L$ and $M$.

f. Give the coordinates of a point, $H$, such that $\overline{EF} \parallel \overline{GH}$.

\[ G: (____, 4), \quad H: (____, ____). \]

g. Explain how you chose the coordinates for $H$. 

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1. Use the coordinate plane below to complete the following tasks.

   a. Identify the locations of \(E\) and \(F\). \(E: (\_, \_)\) \(F: (\_, \_)\)
   
   b. Draw \(\overrightarrow{EF}\).
   
   c. Generate coordinate pairs for \(L\) and \(M\), such that \(\overrightarrow{EF} \parallel \overrightarrow{LM}\).
      \(L: (\_, \_)\) \(M: (\_, \_)\)
   
   d. Draw \(\overrightarrow{LM}\).
1. Use the coordinate plane below to complete the following tasks.

a. Identify the locations of \( M \) and \( N \).  
\[ M: (_____, _____) \quad N: (_____, _____) \]
b. Draw \( \overrightarrow{MN} \).
c. Plot the following coordinate pairs on the plane. 
\[ J: (5, 7) \quad K: (8, 5) \]
d. Draw \( \overrightarrow{JK} \).
e. Circle the relationship between \( \overrightarrow{MN} \) and \( \overrightarrow{JK} \).  
\( \overrightarrow{MN} \perp \overrightarrow{JK} \)  \( \overrightarrow{MN} \parallel \overrightarrow{JK} \)
f. Give the coordinates of a pair of points, \( F \) and \( G \), such that \( \overrightarrow{FG} \parallel \overrightarrow{MN} \).  
\[ F: (_____, _____) \quad G: (_____, _____) \]
g. Draw \( \overrightarrow{FG} \).  

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2. Use the coordinate plane below to complete the following tasks.

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a. Identify the locations of \( A \) and \( B \).  
   \( A: (____, ____), \) \( B: (____, ____), \)

b. Draw \( \overrightarrow{AB} \).

c. Generate coordinate pairs for \( C \) and \( D \), such that \( \overrightarrow{AB} \parallel \overrightarrow{CD} \).
   
   \( C: (____, ____), \) \( D: (____, ____), \)

d. Draw \( \overrightarrow{CD} \).

e. Explain the pattern you used when generating coordinate pairs for \( C \) and \( D \).

f. Give the coordinates of a point, \( F \), such that \( \overrightarrow{AB} \parallel \overrightarrow{EF} \).
   
   \( E: (2\frac{1}{2}, 2\frac{1}{2}), \) \( F: (____, ____), \)

g. Explain how you chose the coordinates for \( F \).
Lesson 14: Construct parallel line segments, and analyze relationships of the coordinate pairs.

Date: 1/31/14
Lesson 15

Objective: Construct perpendicular line segments on a rectangular grid.

Suggested Lesson Structure

- Fluency Practice (12 minutes)
- Concept Development (38 minutes)
- Student Debrief (10 minutes)
- Total Time (60 minutes)

Fluency Practice (12 minutes)

- Multiply and Divide Decimals 5.NBT.7 (3 minutes)
- Draw Angles 4.MD.6 (9 minutes)

Multiply and Divide Decimals (3 minutes)

Materials: (5) Personal white boards

Note: This fluency activity reviews G5–Module 2 concepts.

T: (Write $3 \times 2 = \underline{\phantom{0}}$) What’s $3 \times 2$?
S: 6.
T: (Write $3 \times 2 = 6$. Beneath it, write $0.3 \times 2 = \underline{\phantom{0}}$) What’s $0.3 \times 2$?
S: $0.3 \times 2 = 0.6$.
T: (Write $0.3 \times 2 = 0.6$. Beneath it, write $0.03 \times 2 = \underline{\phantom{0}}$) Write the number sentence.
S: (Write $0.03 \times 2 = 0.06$.)
T: (Write $60 \div 10 = \underline{\phantom{0}}$) What’s $60 \div 10$?
S: 6.
T: (Write $60 \div 10 = 6$. Beneath it, write $6 \div 10 = \underline{\phantom{0}}$) Write the number sentence.
S: (Write $6 \div 10 = 0.6$.)
T: (Write $6 \div 10 = 0.6$. Beneath it, write $6 \div 20 = \underline{\phantom{0}}$) Write the number sentence.
S: (Write $6 \div 20 = 0.3$.)

Continue the process for the following possible suggestions: $6 \div 30$, $25 \div 5$, $25 \div 50$, $1.5 \div 10$, $1.5 \div 30$, $0.12 \div 4$, and $0.12 \div 40$. 
Draw Angles (9 minutes)

Materials: (S) Blank paper, ruler, protractor

Note: This fluency activity informally prepares students for today’s lesson.

Part 1:

T: Use your ruler to draw a 4-inch horizontal line about 3 inches down from the top of your paper.
T: Plot 5 points, one at each inch including 0 inches.
T: Turn to your partner and name pairs of angles whose sums are 90 degree.
S: 45° and 45°. → 30° and 60°. → 25° and 65°.
T: Use the points at zero and 1 inch as the vertices of 2 angles whose sum is 90°.

Part 2:

T: Use your ruler to draw another 4-inch horizontal line about 3 inches below your first one.
T: Plot 5 points, one at each inch including 0 inches.
T: Draw the same angle you made on the top line at the first third inch.
T: Draw the same angle pair you made on the top line but this time, open the angles to the left and let the angle share a vertex with its pair.

Repeat as time allows. Take note informally as to whether the students observe which lines are perpendicular. Students will return to these lines in the Debrief to more closely analyze.

Concept Development (38 minutes)

Materials: (T) Triangle RST template A (with a base of 5 units and a height of 2 units), triangle RST template B (with a height of 2 units and a base of 3 units), angle templates in other various sizes  (S) Straightedge, perpendicular lines recording sheet, angle templates (in various sizes, from G5–M6–Lesson 13) unlined paper

Note: An Application Problem is not included in this lesson in order to provide adequate time for the Concept Development.

Problem 1: Identify perpendicular lines on the grid.

T: (Distribute 1 copy of the perpendicular lines recording sheet to students and display image of Problem (a) on the board.) How do you know if the lines in Problem (a) are perpendicular? Turn and
Lesson 15: Construct perpendicular line segments on a rectangular grid.

Date: 1/31/14

Problem 2: Prove the sum of the acute angles of a given right triangle is 90 degrees by folding.

Note: Demonstrate and pause throughout the constructions as necessary for your students.

T: Take out triangle $RST$ that we used during G5–M6–Lesson 14. (Distribute an unlined piece of paper to each student.)

T: Fold the triangle so that vertex $T'$ and vertex $S$ match up with vertex $R$.

T: What do you notice? Turn and talk.

S: $\angle S$ and $\angle T$ completely cover $\angle R$, with no overlap. $\Rightarrow$ $\angle S$ and $\angle T$ must add up to 90 degrees, because when they’re put together at $\angle R$, they’re the same as $\angle R$. $\Rightarrow$ I did this in fourth grade, $R$ is 90 degrees, so the sum of $S$ and $T$ must be 90 degrees also.

T: Work with your partner. Cut the bottom corner off your blank paper and fold it the same way you folded $\triangle RST$. What do you notice?

T: When one angle of a triangle is a right angle, the measures of the other two angles add up to 90 degrees. (Write $\angle S + \angle T = 90^\circ$.) Keep this in mind as we work today.

Problem 3: Construct perpendicular line segments using the sum of the acute angles and a straightedge.

T: Place your straightedge horizontally across your paper. Then, position triangle $RST'$ so that $\overline{SR}$ runs along your straightedge. (See images to the right.)

T: Use the triangle template to trace $\overline{ST'}$. Then, trace the base and height of the triangle using a dashed line and label the interior angles as $r^\circ$, $s^\circ$, $t^\circ$.

T: Next, slide triangle $RST'$ to the left along your straightedge until $\angle R$ shares a vertex with angle $s^\circ$.

T: Finally, rotate triangle $RST'$ 90 degrees clockwise, and arrange $\overline{RT'}$ so that it forms a straight angle with $\overline{SR}$ along your straightedge.
Lesson 15:
Construct perpendicular line segments on a rectangular grid.

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T: A straight angle measures how many degrees?
S: 180°.

T: Trace $\overline{ST}$, then use dashed lines to trace the shorter sides of the triangle.

T: Now, let’s label the interior angles. (Point to the topmost angle.) This angle has the same measure as which angle in triangle $RST$?
S: $\angle S$.
T: Since it is equal in measure, let’s label it as $s^\circ$ also.
Repeat with the other interior angles.

T: Label the angle formed by the solid segments (as opposed to dashed lines) we’ve drawn as $t^\circ$.

T: (Drag finger along straight line angle at base of figure.) What is the sum of angles on a straight line? In this case, the measures of angles $s^\circ$, $t^\circ$, and $u^\circ$?
S: 180 degrees.
T: What did we learn about the sum of $s^\circ$ and $t^\circ$?
S: They add up to 90 degrees.
T: So, if this straight angle measures 180°, and the sum of these measures (point to $s^\circ$ and $t^\circ$) is 90°, what do we know about the measure of the third angle (point to $u^\circ$).
S: It’s a right angle. $\Rightarrow$ It measures 90 degrees.
T: (Draw right angle symbol on figure.) What is the name we use for segments that form right angles?
S: Perpendicular lines.
T: After sliding and rotating $\triangle RST$, the two longest sides of triangles created perpendicular segments. Use some of the other triangle templates from G5–M6–Lesson 13, and work with a partner to draw other examples of perpendicular segments using this method.

Some students may be ready to work independently, while others may need another guided experience. As students are ready, encourage them to orient their straightedges in a variety of ways on their paper.

Problem 4: Construct perpendicular segments on grid paper.

T: Let’s look again at the perpendicular lines sheet we used earlier. (Display segment (1).) Look at segment (1). Turn and tell your neighbor about a right triangle that has $\overline{ST}$ as its longest side.

T: I see a triangle with a height of 2 units and a base of 3 units. (Draw dashed lines to show this triangle.) Draw the base and height of this triangle on your paper too.
Lesson 15:
Construct perpendicular line segments on a rectangular grid.

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NOTES ON MULTIPLE MEANS OF ENGAGEMENT:
There may be a great disparity in the spatial reasoning abilities among students in the same classroom. Some students may be ready for independent practice rather quickly. If so, let them work independently while others work in a smaller group provided with another guided experience.

NOTES ON MULTIPLE MEANS OF REPRESENTATION:
The method used to construct the perpendicular segments in this lesson may, at first, seem to be an unnecessarily complicated process if the end result is simply to create perpendicular segments. After all, isn’t that what a set square is for? However, taking the time to slide and draw the triangles gives students opportunity to reason about what’s presented on the grid and its foreshadowing of slope which will form the basis of many concepts in future learning.

T: Label the vertex of the right angle as \( R \).

T: Label the vertices of the acute angles of the triangle as \( S \) and \( T \).

T: Remind your neighbor what you know about the measures of \( \angle S \) and \( \angle T \) and how you know it.

S: We found out when we folded the triangle that they are the same as the right angle. They add up to the right angle. \( \Rightarrow \) The sum of \( \angle S \) and \( \angle T \) is 90°.

T: Use triangle \( RST' \) to draw a segment perpendicular to \( ST' \). Talk with a partner as you do so.

S: We can use the grid lines like we used the ruler. I’m going to slide over triangle \( RST \) and then rotate it so that it now has a base of 2 units and a height of 3 units. \( \Rightarrow \) The sum of \( \angle T \) and \( \angle S \) is 90 degrees so the third angle must be 90 degrees since the sum of all three angles is 180.

T: (Allow students time to work.) Yes, you sketched a new triangle, the same as triangle \( RST' \), moved over 3 units and rotated clockwise 90°, so that \( SR \) and \( RT \) create a straight angle. (Slide and rotate.) I’ll use a dashed line to sketch \( RT \) and \( RS \) and a solid line to sketch the longest side, \( ST' \). (Sketch second triangle on board.)

T: (Drag finger along straight line angle at base of figure.) What is the sum of angles on a straight line?

S: 180 degrees.

T: So, if this straight line measures 180°, and \( \angle S \) and \( \angle T \) add up to 90°, what do we know about the angle that’s formed by our solid segments? (Point to area of figure between \( \angle T \) and \( \angle S \).)

S: It’s a right angle. \( \Rightarrow \) It measures 90 degrees. \( \Rightarrow \) The two longest sides of these triangles intersect to make perpendicular segments. (Display segment (2) on board.)

T: Continue to sketch a right triangle for each remaining segment. Then show how that triangle can be moved and sketched again to create a perpendicular segment. Share your work with a neighbor when you’re through. (Circulate to assess progress.)

S: (Work and share.)
Problem Set (10 minutes)

Students should do their personal best to complete the Problem Set within the allotted 10 minutes. For some classes, it may be appropriate to modify the assignment by specifying which problems they work on first. Some problems do not specify a method for solving. Students solve these problems using the RDW approach used for Application Problems.

Student Debrief (10 minutes)

Lesson Objective: Construct perpendicular line segments on a rectangular grid.

The Student Debrief is intended to invite reflection and active processing of the total lesson experience.

Invite students to review their solutions for the Problem Set. They should check work by comparing answers with a partner before going over answers as a class. Look for misconceptions or misunderstandings that can be addressed in the Debrief. Guide students in a conversation to debrief the Problem Set and process the lesson.

You may choose to use any combination of the questions below to lead the discussion.

- In Problem 1, explain how you determined which sets of segments were perpendicular.
- In Problem 3, do your segments look like your neighbor’s line segments? Are there other lines that are perpendicular to the given segments, or is your figure the only correct response?
- How is drawing perpendicular lines similar to and different from drawing parallel lines?
- How do the dimensions of the triangle affect the size of its interior angles?
- Think back on our fluency activity drawing angles. What can you say about the unmarked angles on the line? How was this similar to our work with the triangle templates?
Exit Ticket (3 minutes)

After the Student Debrief, instruct students to complete the Exit Ticket. A review of their work will help you assess the students’ understanding of the concepts that were presented in the lesson today and plan more effectively for future lessons. You may read the questions aloud to the students.
Lesson 15: Construct perpendicular line segments on a rectangular grid.

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Lesson 15: Construct perpendicular line segments on a rectangular grid.

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1. Circle the pairs of segments that are perpendicular.

[Diagram showing several segments on a grid, some of which are perpendicular to each other.]

2. In the space below, use your right triangle templates to draw at least 3 different sets of perpendicular lines.
3. Draw a segment perpendicular to each given segment. Show your thinking by sketching triangles as needed.

4. Draw 2 different lines perpendicular to line \( e \).
1. Draw a segment perpendicular to each given segment. Show your thinking by sketching triangles as needed.
1. Circle the pairs of segments that are perpendicular.

2. In the space below, use your right triangle templates to draw at least 3 different sets of perpendicular lines.
3. Draw a segment perpendicular to each given segment. Show your thinking by sketching triangles as needed.

   a.  
   
   b.  

   c.  
   
   d.  

4. Draw 2 different lines perpendicular to line \( b \).
Triangle $RST$ Template A

Lesson 15: Construct perpendicular line segments on a rectangular grid.

Date: 1/31/14
Lesson 15 Triangle Template B

Triangle $RST$ Template B
Lesson 16

Objective: Construct perpendicular line segments, and analyze relationships of the coordinate pairs.

Suggested Lesson Structure

<table>
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<th>Activity</th>
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<td>Fluency Practice</td>
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<td>Application Problem</td>
<td>7 min</td>
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<tr>
<td>Concept Development</td>
<td>31 min</td>
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<td>Student Debrief</td>
<td>10 min</td>
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<td>Total Time</td>
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Fluency Practice (12 minutes)

- Make Larger Units 4.NF.1
- Draw Angles 4.NF.1

Make Larger Units (4 minutes)

Materials: (S) Personal white boards

Note: This fluency activity reviews G5–Module 3 concepts.

T: (Write $\frac{2}{4} = \_\_\_\_\_)$ Say 2 fourths in larger units.
S: 1 half.
T: (Write $\frac{2}{6} = \_\_\_\_\_)$ Say 2 sixths in larger units.
S: 1 third.
T: (Write $\frac{2}{10} = \_\_\_\_\_)$ Write 2 tenths in larger units.
S: (Write $\frac{2}{10} = \frac{1}{5}$)

Continue the process for $\frac{5}{10}, \frac{3}{6}, \frac{5}{15}, \frac{10}{15}, \frac{3}{12}, \frac{8}{24}, \frac{16}{24}$, and $\frac{21}{28}$.

Draw Angles (8 minutes)

Materials: (S) Blank paper, ruler, protractor

Note: This fluency activity informally prepares students for today’s lesson.
Lesson 16: Construct perpendicular line segments, and analyze relationships of the coordinate pairs.

Date: 1/31/14

T: Use your ruler to draw a 4-inch segment, $\overline{AB}$.

T: Plot a point at the third inch from point $A$.

T: From that point, draw a $30^\circ$ angle that opens to the left. Label its endpoint $C$.

T: From the same point and also opening to the left, draw a $60^\circ$ angle below $AB$. Extend the angle’s side so that it is at least 4 inches long. Label its endpoints $D$ and $E$. (Demonstrate.)

T: Use any tool to draw a segment perpendicular to $\overline{AB}$ with endpoints at $C$ that intersects $\overline{DE}$.

Have students label the intersection of $\overline{AB}$ and $\overline{CF}$ as point $G$. See if they notice that $\angle GCE$, $\angle GFE$ and $\angle FEC$ have angles that are the same measure.

Repeat with other angle pairs as time permits.

Application Problem (7 minutes)

a. Complete the table for the rule $y$ is 1 more than half $x$, graph the coordinate pairs and draw a line to connect them.

b. Give the $y$ coordinate for the point on this line whose $x$-coordinate is $42\frac{1}{4}$.

Bonus: Give the $x$-coordinate for the point on this line whose $y$-coordinate is $5\frac{1}{2}$.

Note: The Application Problem reviews coordinate graphing and fraction multiplication.
Lesson 16: Construct perpendicular line segments, and analyze relationships of the coordinate pairs.

Date: 1/31/14

Concept Development (31 minutes)

Materials: (T) Triangle RST Template A (used in G5–M6–Lesson 15), images of coordinate plane with A, B plotted for display (S) Personal white board, coordinate plane template, straightedge, right angle template RST’ (from G5–M6–Lesson 13)

Problem 1: Slide and rotate right triangle template along coordinate plane to create perpendicular segments.

T: (Distribute coordinate plane template to students and display images of coordinate plane on board with Point A plotted at (3, 1) and Point B plotted at (8, 3).) Say the coordinates of point A.

S: (3, 1.)

T: Record the coordinates of A in the table. Then, plot A on your plane.

T: Tell your neighbor the coordinates of B, record in the table, and plot.

S: (Share, record, and plot.)

T: Use your straightedge to draw AB.

T: Visualize a right triangle that has AB as its longest side and follows the grid lines on its other two sides. Describe this triangle to your partner.

S: I see a triangle below AB. The longer side is 5 units long and the shorter side is 2 units high. The right angle is directly below B. I see a triangle that is above AB. The right angle is 2 units above A. The longer side is 5 units long.

T: Let’s draw the triangle below the segment that you described. Use a dashed line to draw the other sides of the right triangle that has AB as its long side and its right angle’s vertex at (8, 1). (Demonstrate.)

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Lesson 16

Construct perpendicular line segments, and analyze relationships of the coordinate pairs.

T: Tell me what you know about the measures of the acute angles in this triangle.

S: If we folded them over the right angle, they’d cover it perfectly. \( \rightarrow \) The sum of the two acute angles is 90 degrees.

T: Imagine how we could use this triangle and the grid lines to help us draw another segment whose endpoint is \( A \) and is perpendicular to \( \overline{AB} \). Turn and talk.

S: We could slide the triangle to the left like we did yesterday, then turn the triangle up and mark the top vertex. If we connect that point and \( A \), it will be perpendicular. \( \rightarrow \) We don’t have a ruler today, but the grid lines are straight, so we could slide the triangle along the line until the right angle touches \( A \). Then, rotate it 90° clockwise. We mark the top corner and then connect it to \( A \). That segment would be perpendicular to \( \overline{AB} \).

T: After we slide and rotate our imaginary triangle, give the coordinates of the top vertex.

S: \( (1, 6) \).

T: Put these coordinates in your table, plot this point and label it \( C \). Use your straightedge to connect \( C \) and \( A \). What can we say about \( \overline{CA} \) and \( \overline{AB} \)? How do you know?

S: It’s what we did yesterday. The longer side of the first triangle and the shorter side of the second triangle form a straight angle at the bottom of the figure. We know the acute angles add up to 90°, so the angle between them, \( \angle CAB \), must also be 90°.

T: Segments \( \overline{AB} \) and \( \overline{CA} \) are perpendicular segments. Write this in symbols on your personal board. (Write \( \overline{AB} \perp \overline{CA} \) on the board.)

**Problem 2:** Analyze the differences in the coordinate pairs of the perpendicular segments.

T: Put your finger on \( A \), the vertex of \( \angle CAB \).

T: Use the table to compare the \( x \)-coordinates of points \( A \) and \( B \). Tell your neighbor which point has a larger \( x \)-coordinate and why that is true.

S: \( B \) has the larger \( x \) because we traveled to the right on the coordinate plane to get to point \( B \). \( \rightarrow \) We traveled 5 units to the right on the coordinate plane to get to \( B \). \( \rightarrow \) The triangle that has \( \overline{AB} \) as its longest side had a base of 5 units.

T: Now, compare the \( y \)-coordinate of points \( A \) and \( B \). Tell your neighbor which point has a larger \( y \)-coordinate and why that is true.

S: \( B \) also has the larger \( y \) because we traveled up to get to point \( B \). \( \rightarrow \) We traveled 2 units up on the coordinate plane to get to \( B \). \( \rightarrow \) The triangle that was used to draw segment \( \overline{AB} \), had a height of 2 units.

**NOTES ON MULTIPLE MEANS OF ACTION AND EXPRESSION:**

It may have been noted that the triangles that are visualized and drawn by the teacher are consistently those triangles “below” the segment being considered. These are by no means the only triangles that might be used to draw the perpendicular segments. Consider the following figure in which the upper triangles for each segment (drawn in red) are used to construct perpendicular segments (drawn in black).

The use of the triangles below give rise to greater opportunity to reason about angles and their relationships, but students who visualize alternate triangles should not be discouraged from using them to produce the segments.
T: Put your finger back on \( A \), the vertex of \( \triangle CAB \).

T: Think about how many units to the left the triangle was slid and how rotating the triangle located point \( C \). Compare the way you moved your finger for each triangle. Turn and talk.

S: Instead of moving right and then up, this time we moved left and then up. \( \rightarrow \) First, we moved over 5 then up 2, now we move over 2 then up 5. The number of units is the same but they’re switched. \( \rightarrow \)

In both cases the \( y \)-coordinate is being increased, but this time we’re moving left 2 units, and that will make the \( x \)-coordinate less. \( \rightarrow \) That’s because we rotated the triangle!

T: Compare the coordinates of \( A \) and \( C \). How do they differ?

S: The \( x \)-coordinate of \( C \) is 2 less than \( A \), but the \( y \)-coordinate is 5 more. \( \rightarrow \) You have to move 2 to the left and 5 up from \( A \) to get to \( C \).

T: What do you notice about how the coordinates of \( A \) and \( B \) differ, compared to how the coordinates of \( A \) and \( C \) differ? Turn and talk.

S: Both times there’s a difference of 5 units and 2 units. \( \rightarrow \) In \( A \) and \( B \), the difference in the \( x \)-coordinates is 5, then 5 is the difference between the \( y \)-coordinates in \( A \) and \( C \). \( \rightarrow \) It all has to do with the triangles on the plane. They’re the same triangle, but they’re being moved and rotated so they change the coordinates by 5 units and 2 units.

T: What are the other side lengths of the triangle we used to construct the perpendicular lines?

S: 5 units and 2 units. \( \rightarrow \) It’s the base and height of the triangles that tell us the change in the coordinates!

T: Right, so in this case the coordinates change by 5 and 2 units. Since the same sized triangle is used to construct the perpendicular segments, the \( x \)-coordinates changes by 5 or by 2 and the \( y \)-coordinate changes by 5 or by 2. (Point to clarify.)

Repeat the process with \( DEF \) and \( GHI \) (as pictured below).

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**Problem Set (10 minutes)**

Students should do their personal best to complete the Problem Set within the allotted 10 minutes. For some classes, it may be appropriate to modify the assignment by specifying which problems they work on first. Some problems do not specify a method for solving. Students solve these problems using the RDW approach used for Application Problems.
Lesson 16: Construct perpendicular line segments, and analyze relationships of the coordinate pairs.

Student Debrief (10 minutes)

Lesson Objective: Construct perpendicular line segments, and analyze relationships of the coordinate pairs.

The Student Debrief is intended to invite reflection and active processing of the total lesson experience.

Invite students to review their solutions for the Problem Set. They should check work by comparing answers with a partner before going over answers as a class. Look for misconceptions or misunderstandings that can be addressed in the Debrief. Guide students in a conversation to debrief the Problem Set and process the lesson.

You may choose to use any combination of the questions below to lead the discussion.

- Talk about the triangle that you see when you look at $\overline{AB}$ and $\overline{AC}$.
- Tell your neighbor about how visualizing the triangles helps you locate the points needed to draw a perpendicular line.
- In Problem 1, are there other segments that are perpendicular to $\overline{AB}$? Explain how you know.
- Explain your thought process as you solved Problem 3.

Exit Ticket (3 minutes)

After the Student Debrief, instruct students to complete the Exit Ticket. A review of their work will help you assess the students’ understanding of the concepts that were presented in the lesson today and plan more effectively for future lessons. You may read the questions aloud to the students.
Lesson 16 Problem Set

1. Use the coordinate plane below to complete the following tasks.

   a. Draw $\overline{AB}$
   b. Plot point $C$ (0, 8).
   c. Draw $\overline{AC}$.
   d. Explain how you know $\angle CAB$ is a right angle without measuring it.
   e. Sean drew the picture to the right to find a segment perpendicular to $\overline{AB}$. Explain why Sean is correct.
2. Use the coordinate plane below to complete the following tasks.

   a. Draw $\overline{QT}$.
   b. Plot point $R (2, 6 \frac{1}{2})$.
   c. Draw $\overline{QR}$.
   d. Explain how you know $\angle RQT$ is a right angle without measuring it.

   e. Compare the coordinates of points $Q$ and $T$. What is the difference of the $x$-coordinates? The $y$-coordinates?

   f. Compare the coordinates of points $Q$ and $R$. What is the difference of the $x$-coordinates? The $y$-coordinates?

   g. What is the relationship of the differences you found in (e) and (f) to the triangles of which these two segments are a part?

3. $\overline{EF}$ contains the following points. $E: (4, 1)$ $F: (8, 7)$

   a. Give the coordinates of a pair of points $G$ and $H$, such that $\overline{EF} \perp \overline{GH}$.

      $G: (____, ____)$  $H: (____, ____)$
1. Show your thinking on the plane.
   a. Draw $\overline{UV}$.
   b. Plot point $W\ (4\frac{1}{2}, 6)$.
   c. Draw $\overline{VW}$.
   d. Explain how you know that $\angle UVW$ is a right angle without measuring it.
Lesson 16: Construct perpendicular line segments, and analyze relationships of the coordinate pairs.

Date: 1/31/14

1. Use the coordinate plane below to complete the following tasks.

   a. Draw $\overline{PQ}$.
   b. Plot point $R$ (7, 7).
   c. Draw $\overline{PR}$.
   d. Explain how you know $\angle PQR$ is a right angle without measuring it.

   e. Compare the coordinates of points $P$ and $Q$. What is the difference of the $x$-coordinates? The $y$-coordinates?

   f. Compare the coordinates of points $P$ and $R$. What is the difference of the $x$-coordinates? The $y$-coordinates?

   g. What is the relationship of the differences you found in (e) and (f) to the triangles of which these two segments are a part?
2. Use the coordinate plane below to complete the following tasks.

   a. Draw $\overline{BC}$.
   b. Plot point $D (3, 2\frac{1}{2})$.
   c. Draw $\overline{BD}$.
   d. Explain how you know $\angle BCD$ is a right angle without measuring it.

   e. Compare the coordinates of points $B$ and $C$. What is the difference of the $x$-coordinates? The $y$-coordinates?

   f. Compare the coordinates of points $B$ and $D$. What is the difference of the $x$-coordinates? The $y$-coordinates?

   g. What is the relationship of the differences you found in (e) and (f) to the triangles of which these two segments are a part?

3. $\overline{ST}$ contains the following points. $S: (2, 3)$  $T: (9, 6)$

   a. Give the coordinates of a pair of points, $U$ and $V$, such that $\overline{ST} \perp \overline{UV}$.

      $S: (____, ____)$  $T: (____, ____)$
Lesson 16: Construct perpendicular line segments, and analyze relationships of the coordinate pairs.

Date: 1/31/14
Lesson 17

Objective: Draw symmetric figures using distance and angle measure from the line of symmetry.

Suggested Lesson Structure

- Fluency Practice (11 minutes)
- Application Problem (7 minutes)
- Concept Development (32 minutes)
- Student Debrief (10 minutes)

Total Time (60 minutes)

Fluency Practice (11 minutes)

- Make Larger Units 4.NF.1 (3 minutes)
- Subtract a Fraction from a Whole 4.NF.3 (4 minutes)
- Draw Perpendicular Lines Using a Set Square 4.G.1 (4 minutes)

Make Larger Units (3 minutes)

Materials: (S) Personal white boards

Note: This fluency activity reviews G5–Module 3 concepts.

T: (Write $\frac{3}{6}$.) Say 3 sixths in larger units.
S: 1 half.
T: (Write $\frac{3}{9}$.) Say 3 ninths in larger units.
S: 1 third.
T: (Write $\frac{3}{15}$.) Write 3 fifteenths in larger units.
S: (Write $\frac{3}{15} = \frac{1}{5}$.)

Continue the process for $\frac{4}{10}$, $\frac{4}{12}$, $\frac{5}{20}$, $\frac{6}{15}$, $\frac{3}{12}$, $\frac{6}{18}$, $\frac{7}{21}$, $\frac{14}{28}$, $\frac{8}{32}$, and $\frac{24}{32}$.
Lesson 17:

Subtract a Fraction from a Whole (4 minutes)

Materials:  (S) Personal white boards

Note: This fluency activity reviews G5—Module 3 concepts.

T: What’s $1 - \frac{2}{4}$?
S: $\frac{1}{2} \rightarrow \frac{2}{4}$.
T: What’s $1\frac{1}{4} - \frac{1}{2}$?
S: $\frac{3}{4}$.
T: (Write $1\frac{1}{4} - \frac{1}{2} = \frac{3}{4}$.)
T: (Beneath $1\frac{1}{4} - \frac{1}{2} = \frac{3}{4}$, write $2\frac{1}{4} - \frac{1}{2}$) What’s $2\frac{1}{4} - \frac{1}{2}$?
S: $1\frac{3}{4}$.
T: (Write $1\frac{1}{4} - \frac{1}{2} = \frac{3}{4}$.)
T: (Beneath $1\frac{1}{4} - \frac{1}{2} = \frac{3}{4}$, write $6\frac{1}{4} - \frac{1}{2}$) What’s $6\frac{1}{4} - \frac{1}{2}$?
S: $5\frac{3}{4}$.
T: (Write $6\frac{1}{4} - \frac{1}{2} = 5\frac{3}{4}$.)

Continue the process for the following possible suggestions: $1\frac{1}{6} - \frac{1}{3}$, $2\frac{1}{6} - \frac{1}{3}$, $3\frac{1}{6} - \frac{1}{3}$, $7\frac{1}{6} - \frac{1}{3}$, $1\frac{1}{6} - \frac{1}{3}$, $2\frac{1}{8} - \frac{3}{4}$, $5\frac{1}{8} - \frac{3}{4}$, and $9\frac{1}{8} - \frac{3}{4}$.

Draw Perpendicular Lines using a Set Square (4 minutes)

Materials:  (S) Set square, unlined paper

T: Draw a horizontal 4 inch segment $\overline{AB}$ on your paper.
T: Use your set square to draw a $1\frac{3}{4}$ inch segment $\overline{AD}$ perpendicular to $\overline{AB}$.
T: Extend that segment $1\frac{3}{4}$ inch on the other side of $\overline{AB}$.
T: What is the total length of the segment perpendicular to $\overline{AB}$?

Repeat the sequence drawing other lines perpendicular to $\overline{AB}$ using the following suggested lengths: 2.5 cm, $1\frac{3}{8}$ cm, and $1\frac{7}{10}$ cm.
Application Problem (7 minutes)

Materials: (S) Straightedge

Plot (10, 8) and (3, 3) on the coordinate plane, connect with a straightedge, and label as $C$ and $D$.

a. Draw a segment parallel to $\overline{CD}$.
b. Draw a segment perpendicular to $\overline{CD}$.

Note: This Application Problem applies plotting concepts from G5–M6–Lessons 14 and 16.
Concept Development  (32 minutes)

Materials:  (S) Unlined paper, set square, ruler

Problem 1:  Draw symmetric points about a line of symmetry.

Note:  Demonstrate each of the following steps for students giving the work time appropriate for students in the class.

T:  (Distribute unlined paper to each student.)  Use your ruler as a straightedge to draw a segment on your paper.  This will be our line of symmetry.  (This is Step 1, as pictured to the right.)

T:  Next, draw a dark point off the line and label it A.  (This is Step 2.)

T:  Fold the page along this line of symmetry.

T:  Then, rub the area of the paper behind A using some pressure with your finger or eraser.  (This is Step 3.)

T:  Unfold your paper.  You should be able to now see a faint point on the other side of the line.  (This is Step 4.)

T:  Darken this point and label it B.  Then, use your straightedge to lightly draw a segment connecting these two points.  (This is Step 5.)

T:  Measure the angles formed by the segment and \( \overline{AB} \).  What do you find?

S:  All the angles are \( 90^\circ \).  \( \rightarrow \) The segment is perpendicular to the line.

T:  Use your ruler to measure the distance between each point and the line along the segment.  What do you find?

S:  The segments are the same length.  \( \rightarrow \) The points are the same distance from the line along the segments.

Repeat this sequence for another point off the line.

T:  Using what we've just discovered about this pair of symmetric points, draw another pair of points without folding and rubbing our paper.  Talk to your partner as you work.

S:  (Work and discuss.)

T:  Let's do another together.  I'll guide you through.  Draw another point off the line.

T:  Use your set square to draw a segment that crosses the line of symmetry at a 90 degree angle and includes your point.  (Demonstrate.)
Lesson 17:

Draw symmetric figures using distance and angle measure from the line of symmetry.

Date: 1/31/14

Possible quadrilaterals:

**Problem 2: Draw symmetric figures about a line of symmetry.**

T: Use your ruler to measure the distance from your point to the line of symmetry along the perpendicular segment that you drew.

T: Measure the same distance along the perpendicular segment on the opposite side of the line of symmetry and draw a point.

T: Since these points were drawn using a line perpendicular to the line of symmetry and are equidistant from the line of symmetry, we say they are symmetric about the line.

T: Practice drawing other sets of corresponding points about different lines of symmetry. Use any method that works for you.

T: Use your ruler to measure the distance from your point to the line of symmetry along the perpendicular segment that you drew.

T: Measure the same distance along the perpendicular segment on the opposite side of the line of symmetry and draw a point.

T: Since these points were drawn using a line perpendicular to the line of symmetry and are equidistant from the line of symmetry, we say they are symmetric about the line.

T: Practice drawing other sets of corresponding points about different lines of symmetry. Use any method that works for you.

**NOTES ON MULTIPLE MEANS OF ENGAGEMENT:**

Students with fine motor deficits may benefit from being paired with another student for drawing the figures. One partner might draw while the other is responsible for measuring the segments in order to place the points.

**Problem 2: Draw symmetric figures about a line of symmetry.**

T: Draw a line of symmetry.

T: Draw a point, \(A\), off the line.

T: Draw a second point, \(B\), on the same side of the line as \(A\).

T: Draw \(AB\).

T: How is this drawing different from the ones we did earlier?

S: We drew 2 points this time. \(\rightarrow\) The other ones were just a point, but now we have a segment.

T: Show your neighbor how you’ll draw a point symmetric to \(A\) about the line. Name it \(C\). (Allow students time to share.)

T: Work independently to draw a point symmetric to \(B\). Name it \(D\).

T: Draw \(CD\). Compare \(AB\) to \(CD\). What do you notice? Turn and talk.

S: They’re the same length. \(\rightarrow\) They’re the same length, but they are mirror images of each other.

T: We can say that \(AB\) is symmetric to \(CD\) about the line symmetry.

T: Draw another line of symmetry.

T: Draw a point, \(E\), off the line.

T: Draw a second point, \(F\), on the line.

T: Draw \(EF\).

T: Draw a third point, \(G\), on the line.

T: Draw \(EG\).

T: How is this figure different from the one we just did?

S: We drew 3 points this time. \(\rightarrow\) This one is 2 segments. \(\rightarrow\) This figure has 2 points on the line of symmetry, and 1 off of it.

T: You drew points \(F\) and \(G\) on the line of symmetry. Point \(E\), is off the line. Draw a point, \(H\), symmetric
Lesson 17: Draw symmetric figures using distance and angle measure from the line of symmetry.

Date: 1/31/14

NOTES ON MULTIPLE MEANS OF ENGAGEMENT:

Drawing symmetric figures lends itself well to connections with art. Students might use these construction techniques to create symmetric figures by cutting and gluing colored strips of paper or through other media. Students might also enjoy creating inkblots by placing paint in the center of paper, folding, and unfolding. Once the blots are dry, students might measure various parts of their creation from the line of symmetry to confirm the concepts developed in the lesson.

Problem Set (10 minutes)

Students should do their personal best to complete the Problem Set within the allotted 10 minutes. For some classes, it may be appropriate to modify the assignment by specifying which problems they work on first. Some problems do not specify a method for solving. Students solve these problems using the RDW approach used for Application Problems.

Student Debrief (10 minutes)

Lesson Objective: Draw symmetric figures using distance and angle measure from the line of symmetry.

The Student Debrief is intended to invite reflection and active processing of the total lesson experience.

 Invite students to review their solutions for the Problem Set. They should check work by comparing answers with a partner before going over answers as a class. Look for misconceptions or misunderstandings that can be addressed in the Debrief. Guide students in a conversation to debrief the Problem Set and process the lesson.

You may choose to use any combination of the questions below to lead the discussion.

- In Problem 1, should everyone’s solutions look the same? Explain why.
- In Problem 2, did you draw symmetric points for A or D? Why?
- Help Stu fix his mistake. What should he do the next time he draws a symmetric figure?
- What name can we give to all the quadrilaterals we drew in Problem 3? Explain your reasoning.
Exit Ticket (3 minutes)

After the Student Debrief, instruct students to complete the Exit Ticket. A review of their work will help you assess the students’ understanding of the concepts that were presented in the lesson today and plan more effectively for future lessons. You may read the questions aloud to the students.
Lesson 17 Problem Set

1. Draw to create a figure that is symmetric about $\overline{AD}$.

   ![Figure 1](image1.png)

2. Draw precisely to create a figure that is symmetric about $\overline{HI}$.

   ![Figure 2](image2.png)
3. Complete the following construction in the space below.
   a. Plot 3 non-collinear points $D$, $E$, and $F$.
   b. Draw $\overline{DE}$, $\overline{EF}$, and $\overline{DF}$.
   c. Plot point $G$, and draw the remaining sides, such that quadrilateral $DEFG$ is symmetric about $\overline{DF}$.

4. Stu says that quadrilateral $HIJK$ is symmetric about $\overline{HJ}$ because $IL = LK$. Use your tools to determine Stu’s mistake. Explain your thinking.
Name ___________________________________________ Date __________________

1. Draw 2 points on one side of the line below and label them $T$ and $U$.
2. Use your set square and ruler to draw symmetrical points about your line that correspond to $T$ and $U$ and label them $V$ and $W$. 
Lesson 17: Draw symmetric figures using distance and angle measure from the line of symmetry.

1. Draw to create a figure that is symmetric about $\overline{DE}$.

2. Draw to create a figure that is symmetric about $\overline{LM}$. 

Name ___________________________ Date __________________

1. Draw to create a figure that is symmetric about $\overline{DE}$.

2. Draw to create a figure that is symmetric about $\overline{LM}$. 

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3. Complete the following construction in the space below.
   a. Plot 3 non-collinear points, \(G\), \(H\), and \(I\).
   b. Draw \(\overline{GH}, \overline{HI},\) and \(\overline{IG}\).
   c. Plot point \(J\), and draw the remaining sides, such that quadrilateral \(GHJI\) is symmetric about \(\overline{IG}\).

4. In the space below, use your tools to draw a symmetric figure around a line.