



Lesson 6: Drawing Geometric Shapes

Student Outcomes

- Students use a compass, protractor, and ruler to draw geometric shapes based on given conditions.

Lesson Notes

The following sequence of lessons is based on standard **7.G.A.2**: Draw (freehand, with a ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measurements of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle. Instruction including the use of a compass is included to develop deeper understanding of geometric relationships and also as preparation for high school geometry.

By the close of Lesson 6, students should be able to use a ruler, protractor, and compass to draw simple figures. Although students have previously worked with a ruler and protractor, they have negligible experience using a compass before Grade 7. Therefore, they need to be given some time for exercises that demonstrate how to accurately use a compass. Practice through simple constructions will prepare students for Lessons 7–12, which require drawing triangles according to the conditions that determine a unique triangle, more than one triangle, or no triangle. For example, by constructing a triangle with three given side lengths, students gain a better understanding of how the construction is done and why this condition always yields a unique triangle.

As always, teachers should gauge how students handle the early problems and proceed with their students' performance in mind. If students struggle with problems, such as Exploratory Challenge Problems 2 and 3, try giving them variations of the same questions before moving forward. The goal of the lesson is to draw geometric shapes using a compass, protractor, and ruler. If students struggle to develop a facility with these tools, spend more time on the exercises with fewer instructions.

Students should have some experience with freehand sketches. Consider doing some exercises twice, once with a tool and once without. To highlight Mathematical Practice 5, students should have the opportunity to compare creating a diagram with a tool versus doing it freehand.

Classwork

Discussion (5 minutes)

The purpose of this lesson is to develop a familiarity with the tools of construction through problems. Students construct several basic geometric shapes and composite figures. Discuss what a compass is and how to use it.

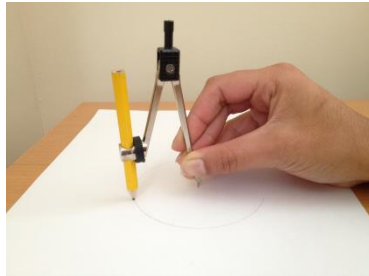
A compass is a tool for drawing circles. The point where the needle of the compass sits represents the center of the circle, and its radius can be adjusted by widening or narrowing the two arms of the compass.

Scaffolding:

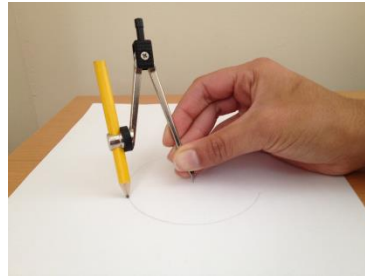
Ten problems are provided, but teachers may choose how many to work through based on students' abilities.

Tips to drawing circles with a thumbscrew compass:

- Adjust the compass to the intended radius length.
- Using one hand, place weight on the point of the compass, and let the pencil-end be relatively loose.
- Angle the compass relative to the paper; holding the compass perpendicular to the paper makes it difficult to maneuver.



Holding the compass perpendicular to the paper makes it difficult to maneuver.



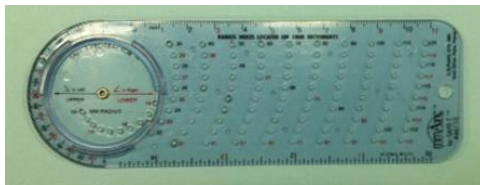
Angling the compass relative to the paper makes it easier to rotate.

What makes using the compass difficult?

- Students using traditional metal compasses might have difficulty with the following: keeping weight on the point while drawing with the pencil, dealing with a pencil coming loose and falling out, and making a hole in the paper with the point. Students using safety compasses might have difficulty keeping weight on the center of the compass, moving the slider around unintentionally, and keeping track of the radius adjustment.

Have students try drawing a few circles of their own before working on the exercises.

There are alternatives to using the kind of compass shown above; here are two examples:



Safety compass



Pencil and String compass

All three kinds of compasses have pros and cons; use whichever seems best for students. Over the next several lessons, a compass is critical in studying the criteria that determine a unique triangle.

Exploratory Challenge (25 minutes)

MP.5

Ideally, the Exploratory Challenge is done in small groups so that students can compare and discuss the constructions as they finish them. After the allotted 25 minutes, or periodically, responses can be discussed as a whole class by sharing individual work from each group. Another option is to post examples of work around the classroom at the end of the Exploratory Challenge and have a gallery walk.

Regarding the rest of the Exploratory Challenge:

- What, if anything, is challenging about the problems?
 - *Reading and following the steps correctly.*
- What can groups do to make sure that everyone proceeds through each problem correctly?
 - *Discuss each step and decide what it means before constructing it. Conversely, groups could do the step, and if there are differences, they could discuss which construction seems correct against the written instruction.*

Exploratory Challenge

Use a ruler, protractor, and compass to complete the following problems.

1. Use your ruler to draw three segments of the following lengths: 4 cm, 7.2 cm, and 12.8 cm. Label each segment with its measurement.

_____ 4 cm

_____ 7.2 cm

_____ 12.8 cm

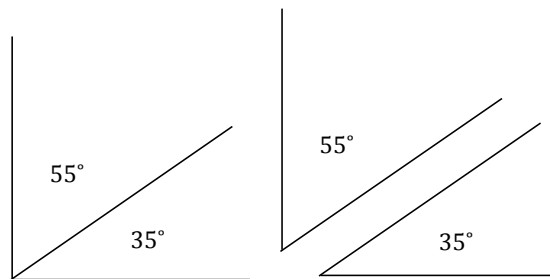
Remind students how to measure angles accurately using a protractor:

1. Place the center notch of the protractor on the vertex.
2. Put the pencil point through the notch, and move the straightedge into alignment.
3. When measuring angles, it is sometimes necessary to extend the sides of the angle so that they intersect with the protractor's scale.

Refer to Grade 4 Module 4 Topic B for more information on how to instruct students to measure angles.

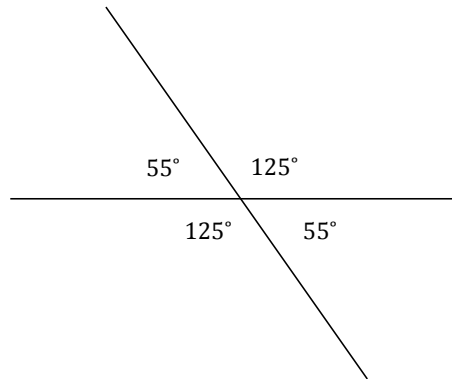
2. Draw complementary angles so that one angle is 35° . Label each angle with its measurement. Are the angles required to be adjacent?

The complementary angles do not need to be adjacent; the sum of the measurements of the angles needs to be 90° .



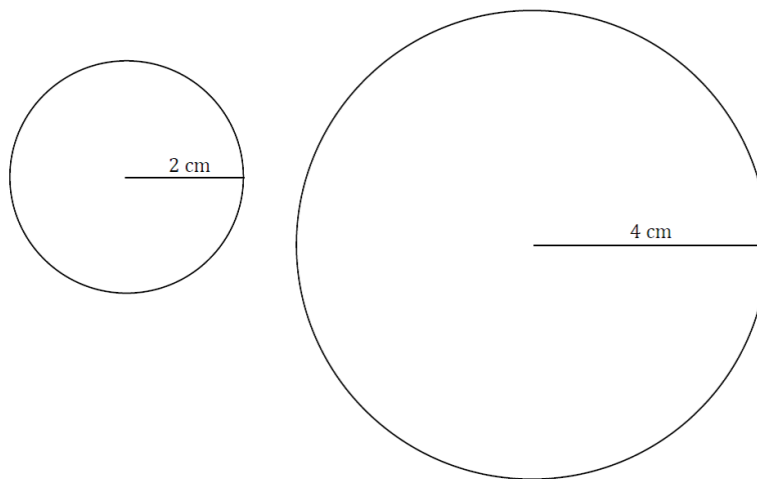
- How will you begin Exploratory Challenge Problem 3?
 - *I will draw an angle with a measurement of 125° and then extend the rays through the vertex so that the figure looks like an X. Since one angle will have a measurement of 125° , the adjacent angle on the line will measure 55° .*

3. Draw vertical angles so that one angle is 125° . Label each angle formed with its measurement.

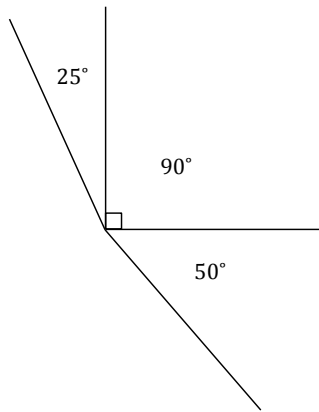


4. Draw three distinct segments of lengths 2 cm, 4 cm, and 6 cm. Use your compass to draw three circles, each with a radius of one of the drawn segments. Label each radius with its measurement.

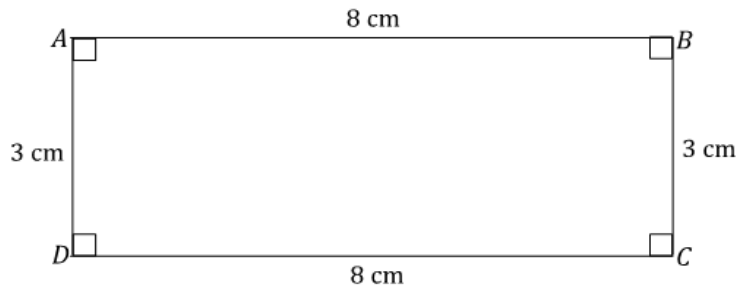
Due to space restrictions, only the two smaller circles are shown here:



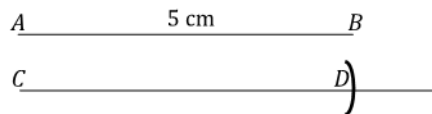
5. Draw three adjacent angles a , b , and c so that $a = 25^\circ$, $b = 90^\circ$, and $c = 50^\circ$. Label each angle with its measurement.



6. Draw a rectangle $ABCD$ so that $AB = CD = 8$ cm and $BC = AD = 3$ cm.



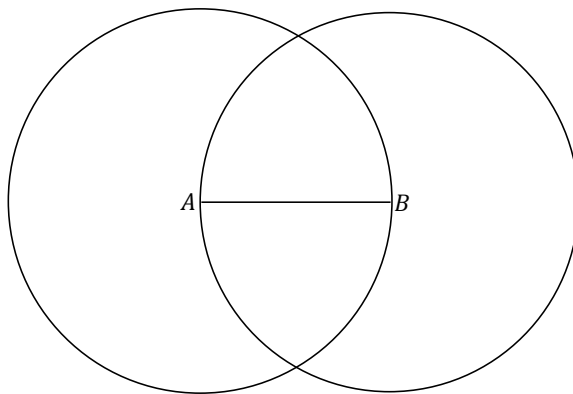
7. Draw a segment AB that is 5 cm in length. Draw a second segment that is longer than \overline{AB} , and label one endpoint C . Use your compass to find a point on your second segment, which will be labeled D , so that $CD = AB$.



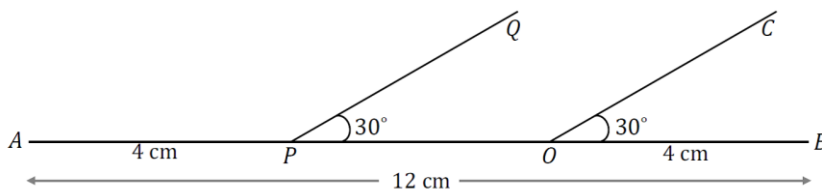
8. Draw a segment AB with a length of your choice. Use your compass to construct two circles:
- A circle with center A and radius AB .
 - A circle with center B and radius BA .

Describe the construction in a sentence.

Two circles with radius AB are drawn; one has its center at A , and the other has its center at B .



9. Draw a horizontal segment AB , 12 cm in length.
- Label a point O on \overline{AB} that is 4 cm from B .
 - Point O will be the vertex of an angle COB .
 - Draw ray OC so that the ray is above \overline{AB} and $\angle COB = 30^\circ$.
 - Draw a point P on \overline{AB} that is 4 cm from A .
 - Point P will be the vertex of an angle QPO .
 - Draw ray PQ so that the ray is above \overline{AB} and $\angle QPO = 30^\circ$.

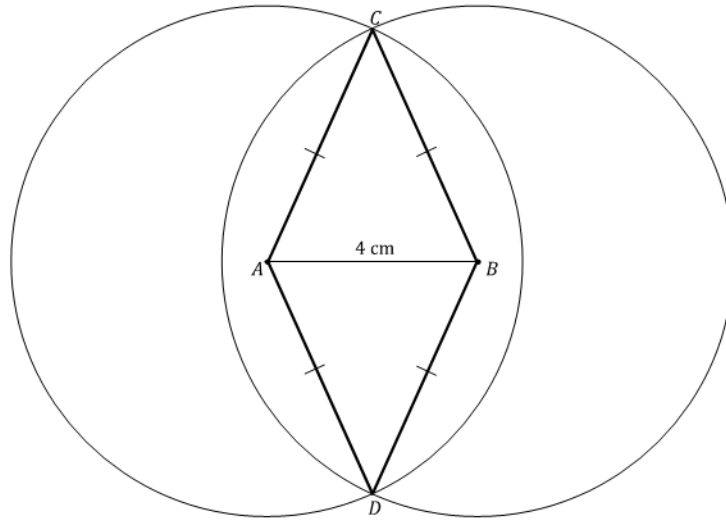


10. Draw segment AB of length 4 cm. Draw two circles that are the same size, one with center A and one with center B (i.e., do not adjust your compass in between) with a radius of a length that allows the two circles to intersect in two distinct locations. Label the points where the two circles intersect C and D . Join A and C with a segment; join B and C with a segment. Join A and D with a segment; join B and D with a segment.

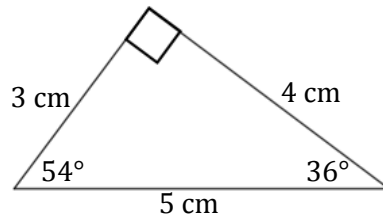
What kind of triangles are $\triangle ABC$ and $\triangle ABD$? Justify your response.

$\triangle ABC$ and $\triangle ABD$ are identical isosceles triangles. Both circles are the same size (i.e., have the same radius). Furthermore, the point along each circle is the same distance away from the center no matter where you are on the circle; this means the distance from A to C is the same as the distance from B to C (the same follows for D). A triangle with at least two sides of equal length is an isosceles triangle.

Possible solution:



11. Determine all possible measurements in the following triangle, and use your tools to create a copy of it.



Discussion (8 minutes)

In the allotted time, review the solutions to each question as a whole group. As suggested previously, share out responses from groups, or have each group put one (or more) response up on a wall and have a gallery walk. Discuss responses to Exploratory Challenge Problems 2, 8, 9, and 10.

- Problem 2: Are the [complementary] angles required to be adjacent?
 - *No, complementary angles can be adjacent but do not have to be. The only requirement is for the sum of the measurements of the two angles to be 90° .*
- Problem 8: Describe the construction in a sentence.
 - *Two circles with radius AB are drawn; one has its center at A , and the other has its center at B .*
- Problem 9: How would you describe the relationship between rays OC and PQ ?
 - *Rays OC and PQ appear to be parallel since they both tilt or slant at the same angle to segment AB .*
- For Problem 10, emphasize that the construction requires two circles of the same size as well as circles that intersect in two locations. Problem 10: What kind of triangles are $\triangle ABC$ and $\triangle ABD$? Justify your response.
 - *$\triangle ABC$ and $\triangle ABD$ are isosceles triangles. Both circles are the same size (i.e., have the same radius). Furthermore, the point along each circle is the same distance away from the center no matter where you are on the circle. This means the distance from A to C is the same as the distance from B to C (as is the case for D). A triangle with at least two sides of equal length is an isosceles triangle.*

Closing (2 minutes)

- Three tools were used to complete the problems in the Exploratory Challenge, two of which you have already used in the last few years. What did the problems show you about the ways in which you can use a compass?
 - *A compass can be used to construct circles, to measure and mark off a segment of equal length to another segment, and to confirm the fact that the radius of the center of a circle to the circle itself remains constant no matter where you are on the circle (Problem 10).*

Lesson Summary

The compass is a tool that can be used for many purposes that include the following:

- **Constructing circles.**
- **Measuring and marking a segment of equal length to another segment.**
- **Confirming that the radius of the center of a circle to the circle itself remains constant no matter where you are on the circle.**

Exit Ticket (5 minutes)



Name _____

Date _____

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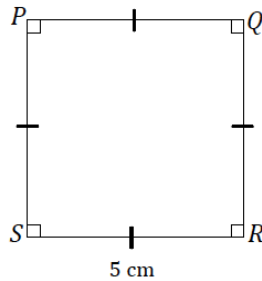
Exit Ticket

1. Draw a square $PQRS$ with side length equal to 5 cm. Label the side and angle measurements.

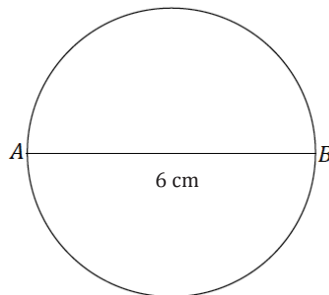
2. Draw a segment AB , 6 cm in length. Draw a circle whose diameter is segment AB .

Exit Ticket Sample Solutions

1. Draw a square $PQRS$ with side length equal to 5 cm. Label the side and angle measurements.



2. Draw a segment AB , 6 cm in length. Draw a circle whose diameter is segment AB .

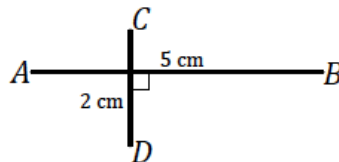


Problem Set Sample Solutions

Use a ruler, protractor, and compass to complete the following problems.

1. Draw a segment AB that is 5 cm in length and perpendicular to segment CD , which is 2 cm in length.

One possible solution:



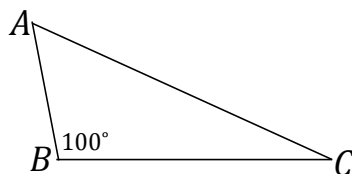
2. Draw supplementary angles so that one angle is 26° . Label each angle with its measurement.

Possible solutions:



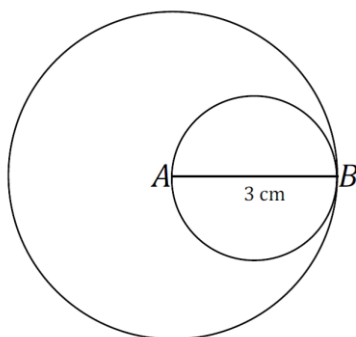
3. Draw $\triangle ABC$ so that $\angle B$ has a measurement of 100° .

One possible solution:



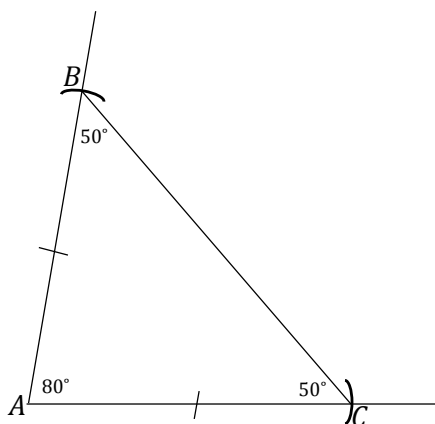
4. Draw a segment AB that is 3 cm in length. Draw a circle with center A and radius AB . Draw a second circle with diameter AB .

One possible solution:



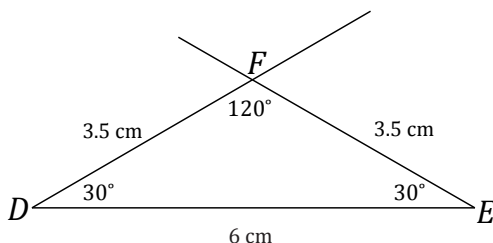
5. Draw an isosceles $\triangle ABC$. Begin by drawing $\angle A$ with a measurement of 80° . Use the rays of $\angle A$ as the equal legs of the triangle. Choose a length of your choice for the legs, and use your compass to mark off each leg. Label each marked point with B and C . Label all angle measurements.

One possible solution:



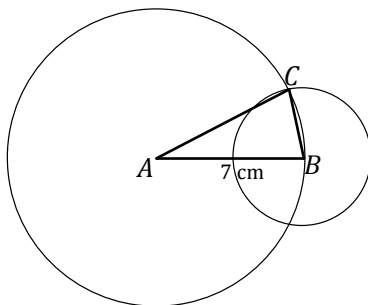
6. Draw an isosceles $\triangle DEF$. Begin by drawing a horizontal segment DE that is 6 cm in length. Use your protractor to draw $\angle D$ and $\angle E$ so that the measurements of both angles are 30° . If the non-horizontal rays of $\angle D$ and $\angle E$ do not already cross, extend each ray until the two rays intersect. Label the point of intersection F . Label all side and angle measurements.

One possible solution:

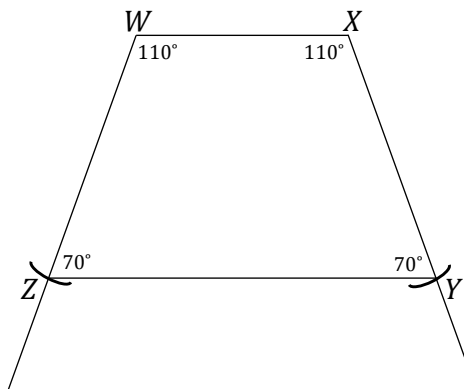


7. Draw a segment AB that is 7 cm in length. Draw a circle with center A and a circle with center B so that the circles are not the same size, but do intersect in two distinct locations. Label one of these intersections C . Join A to C and B to C to form $\triangle ABC$.

One possible solution:



8. Draw an isosceles trapezoid $WXYZ$ with two equal base angles, $\angle W$ and $\angle X$, that each measures 110° . Use your compass to create the two equal sides of the trapezoid. Leave arc marks as evidence of the use of your compass. Label all angle measurements. Explain how you constructed the trapezoid.



Draw segment WX . Use a protractor and segment WX to draw $\angle XWZ$ at a measurement of 110° ; do the same to draw $\angle WXY$. (Note: When drawing \overline{WZ} and \overline{XY} , length is not specified, so students should have rays long enough so that they can use a compass to mark off lengths that are the same along each ray in the next step.) Place the point of the compass at W , adjust the compass to a desired width, and mark an arc so that it crosses \overline{WZ} . Label the intersection as Z . Do the same from X along \overline{XY} , and mark the intersection as Y . Finally, join Z and Y to form isosceles trapezoid $WXYZ$.