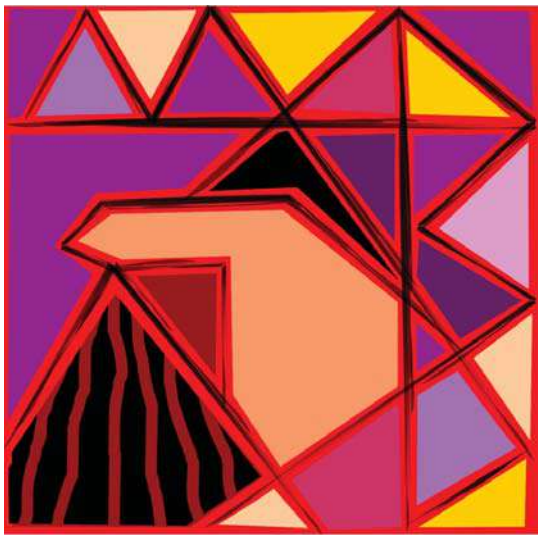
1.16 Vertical Angles

Here you'll learn to identify adjacent and vertical angles formed by intersecting lines and then find missing angle measures.



When the students arrived at the art museum, Mrs. Gilson pointed out some of the art work in the courtyard of the museum. One of the paintings was considered "street art" and was immediately noticed by Tania and her friend Yalisha. The two girls walked all around the painting which was about five feet by five feet and stretched across an entire wall.

"This is really cool," Tania commented. "I love the way the lines intersect. I think that this is a painting all about lines."

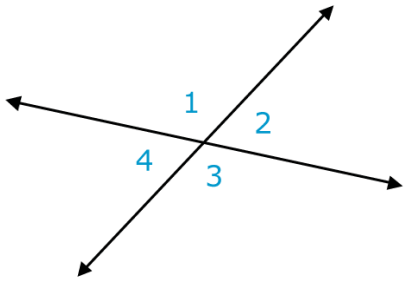
"Me too," Yalisha agreed. "However, there are angles here too. If you look, you can see that when the lines intersect they form different angles. For example, look at the small dark purple triangle and the light purple quadrilateral. The angles formed by those lines are exactly the same. Did you know that?"

"How can that be? One shape is so much larger than the other?" Tania asked puzzled.

How can it be? What it is about the relationship between these lines that makes the angles the same or not the same? This Concept is all about angles and special pairs of angles. Keep Tania's question in mind as you work through this Concept. At the end, see if you can figure out why Yalisha says that the angles are the same.

Guidance

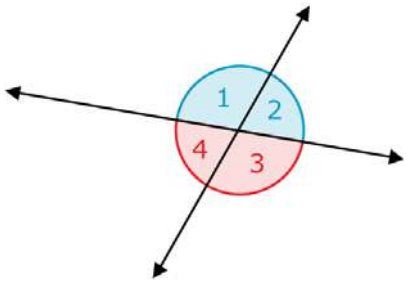
In this Concept, we will look at the relationships among angles formed by intersecting lines. Some lines never intersect. Others do, and when they do, they form angles. Take a look at the intersecting lines below.



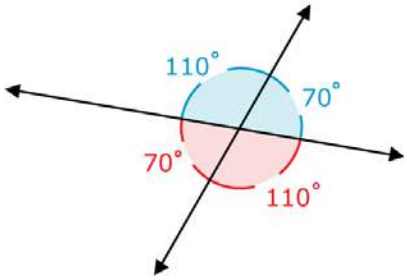
The angles formed by the two intersecting lines are numbered 1 through 4. In this lesson, we will learn how to find the measure of these angles, given the measure of any one of them.

Let's look at the relationships formed between the angles created when two lines intersect.

Adjacent angles **are angles that share the same vertex and one common side.** If they combine to make a straight line, adjacent angles must add up to 180°. Below, angles 1 and 2 are adjacent. Angles 3 and 4 are also adjacent. Adjacent angles can also be thought of as "next to" each other.



Can you see that angles 1 and 2, whatever their measurements are, will add up to 180°**? This is true for angles 3 and 4, because they also form a line. But that's not all. Angles 1 and 3 also form a line. So do angles 2 and 4. These are also pairs of adjacent angles.** Let's see how this works with angle measurements.



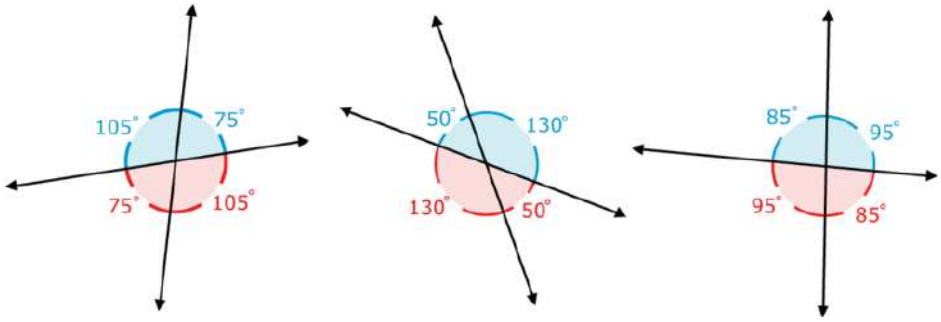
The sum of each angle pair is 180°. **Using the vocabulary from the last section, you can also see that these angle pairs are *supplementary.***

This pattern of adjacent angles forms whenever two lines intersect. Notice that the two angles measuring 110° are diagonal from each other, and the two angles measuring 70° are diagonal from each other. This is the other special relationship among pairs of angles formed by intersecting lines.

What are angles on the diagonal called?

These angle pairs are called ***vertical angles.*** **Vertical angles are always equal.** Angles 1 and 4 above are vertical angles, and angles 2 and 3 are vertical angles.

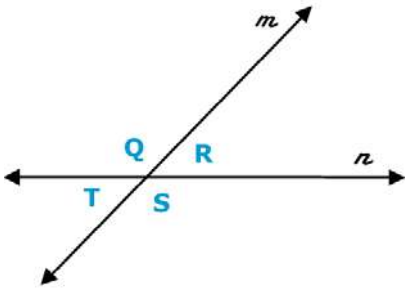
These relationships always exist whenever any two lines intersect. Look carefully at the figures below. Understanding the four angles formed by intersecting lines is a very important concept in geometry.



In each figure, there are pairs of adjacent angles that add up to 180° and pairs of vertical angles that are equal and opposite each other.

Now let's practice recognizing adjacent and vertical angle pairs.

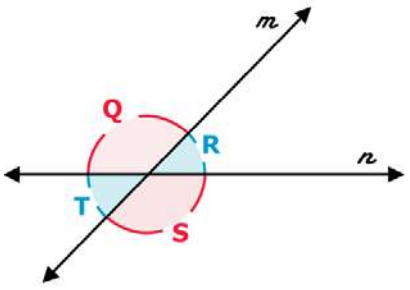
Identify all of the pairs of adjacent angles and the two pairs of vertical angles in the figure below.

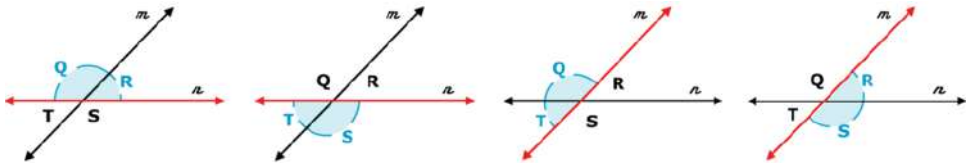


Hey, there aren't any numbers! How are we supposed to know the measures of the four angles? Well, we actually don't need to know them to answer the question. As we have said, adjacent and vertical relationships never change, no matter what the measures of the angles are. The pairs of adjacent angles will always form a straight line, and the pairs of vertical angles will always be opposite each other.

With this in mind, let's look for the adjacent angles. Adjacent angles share a side and, in the case of intersecting lines, will together form a straight line. Which adjacent angles form line n? Angles Q and R are next to each other and together make a straight angle along line n. What about T and S? They also sit together along line n. Both are adjacent pairs. Now let's look at line m. Which pairs of angles together make a straight angle along line m? Angles Q and T do, and so do angles S and R. All four of these pairs are adjacent.

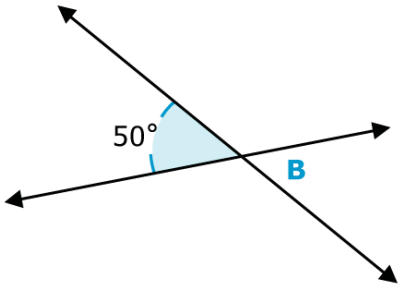
Now let's look for the vertical angles. Remember, vertical angles are equal and opposite each other. Which angles are across from each other? Angles Q and S are, and we know that these have the same measure, whatever the measure is. Angles T and R, the small angles, are also opposite each other. Therefore they are the other pair of vertical angles.





We can use what we have learned about adjacent and vertical angles to find the measure of an unknown angle formed by intersecting lines. We know that adjacent angles add up to 180° and that vertical angles are equal. Therefore if we are given the measure of one angle, we can use its relationship to another angle to find the measure of the second angle.

Find the measure of angle *B* below.

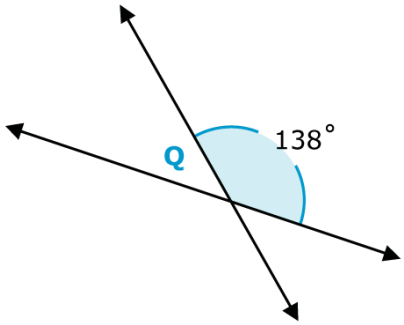


We know that one angle measures 50, and we want to find the measure of angle *B*.

First we need to determine how these two angles are related. Is angle *B* adjacent or vertical to the known angle? It is opposite, so **these two angles are vertical angles.** And we already know that vertical angles are always equal, so **angle** *B***must also be** 50°.

Here is another one.

Find the measure of $\angle Q$ below.



Again, we need to find how the known angle and the unknown angle are related. This time angle $Q$is not opposite the known angle. It is adjacent, because together they form a straight line. What do we know about adjacent angles? **They add up to** 180°. Therefore we can use the measure of the known angle to solve for angle Q.

$$\begin{aligned} 138^\circ + \angle Q &= 180 \\ \angle Q &= 180 - 138 \\ \angle Q &= 42^\circ \end{aligned}$$

Angle Qmust be 42°.

Now answer these questions about vertical and adjacent angles.

Example A

What does the word "adjacent" mean?

Solution: Next to

Example B

True or false. Adjacent angles have the same measure?

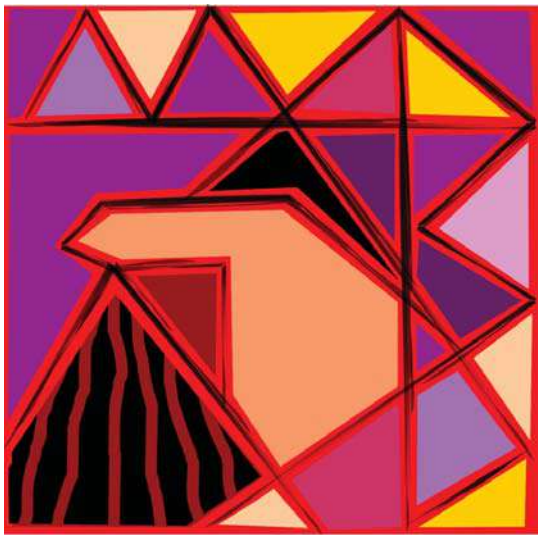
Solution: False

Example C

True or false. Vertical angles have the same measure?

Solution: True

Here is the original problem onceagain.



Have you been thinking about Tania's question? Reread this situation and then write down your answer to her question. Are these two angles the same or aren't they? Why or why not?

When the students arrived at the art museum, Mrs. Gilson pointed out some of the art work in the courtyard of the museum. One of the paintings was considered "street art" and was immediately noticed by Tania and her friend Yalisha. The two girls walked all around the painting which was about five feet by five feet and stretched across an entire wall.

"This is really cool," Tania commented. "I love the way the lines intersect. I think that this is a painting all about lines."

"Me too," Yalisha agreed. "However, there are angles here too. If you look, you can see that when the lines intersect they form different angles. For example, look at the small dark purple triangle and the light purple quadrilateral. The angles formed by those lines are exactly the same. Did you know that?"

"How can that be? One shape is so much larger than the other?" Tania asked puzzled.

Let's think about Tania's question. The size of the angles isn't a function of whether or not the shapes are large or not. It has to do with the intersection of the lines. Remember how Tania commented that she thought that the painting was all about lines, well, here is where her point is valid.

First, think about what type of angles are formed by the two intersecting lines. We have vertical angles. Any time two lines intersect, the opposing angles formed by the intersection of those two lines is considered vertical angles. Vertical angles are congruent. Therefore, Yalisha's comment is accurate.

Now look at the painting again. Can you find a pair of adjacent angles? Can you find another pair of vertical angles? Make a few notes in your notebook.

Vocabulary

Here are the vocabulary words in this Concept.

Adjacent Angles
angles formed by intersecting lines that are supplementary and are next to each other. The sum of their angles is 180°.

Vertical Angles
angles formed by intersecting lines that are on the diagonals. They have the same measure.

Supplementary
having a sum of 180°.

Intersecting Lines
lines that cross at one point.

Parallel Lines
lines that will never cross.

Perpendicular Lines
lines that intersect at a right angle.

Corresponding Angles
Angles that are in the same place in each intersection when a line crosses two parallel lines.

Guided Practice

Here is one for you to try on your own.

Two lines intersect. One vertical angle has a measure of 45° What is the measure of the angle adjacent to it?

Answer

To figure this out, we can use what we know about vertical and adjacent angles.

Two lines are intersecting, the number of degrees in a straight line is 180°.

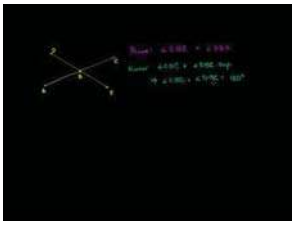
The known angle is 45°. Therefore, we can subtract this angle from 180 to find the number of degrees in the angle next to the vertical angles.

$180 - 45 = 145$

The adjacent angle has a measure of 145°**.**

Video Review

Here is a video for review.



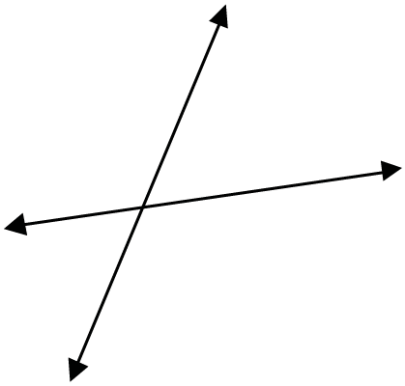
MEDIA
Click image to the left for more content.

- This is a James Sousa video oncomplementary and supplementaryangles.

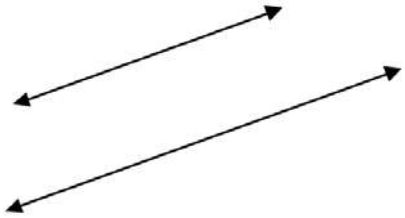
Practice

Directions: Identify whether the lines below are parallel, perpendicular, or just intersecting.

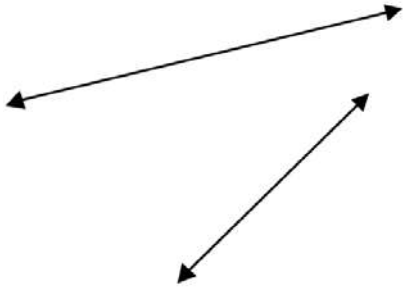
1.



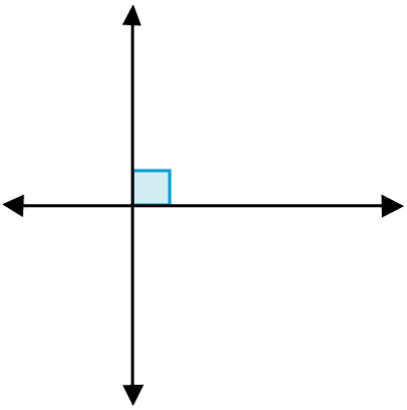
2.



3.



4.



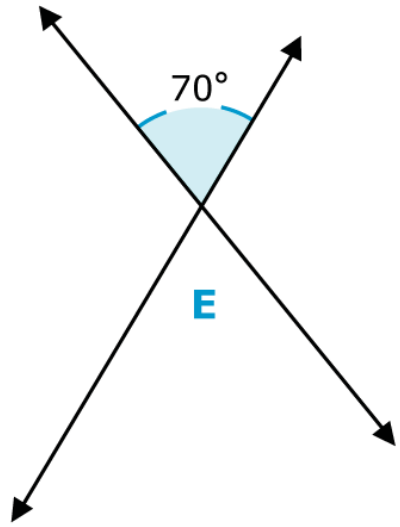
5. Lines that will never intersect.

6. Lines that intersect at a 90° angle.

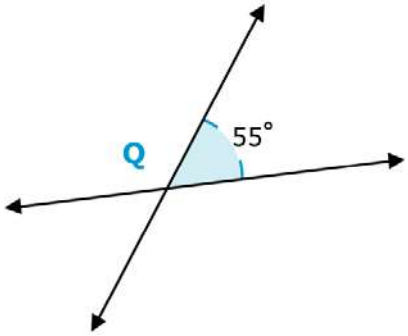
7. Lines that cross at one point.

Directions: Tell whether the pairs of angles are adjacent or vertical.

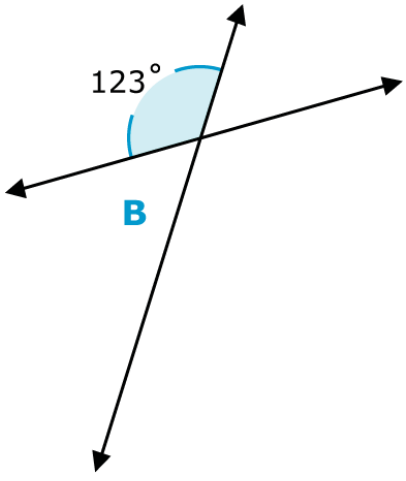
8.



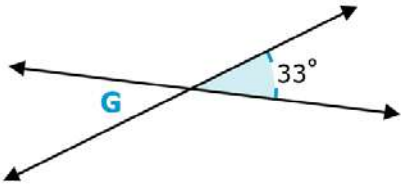
9.



10.



11.



12. Two angles with the same measure.

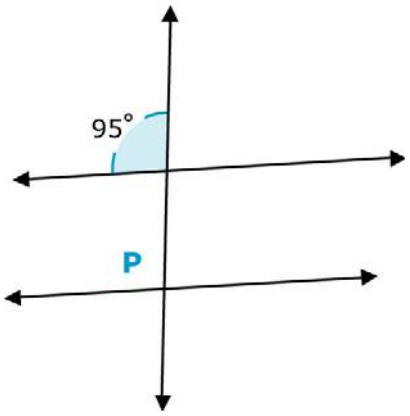
13. An angle next to another angle.

14. An angle that is congruent to another angle.

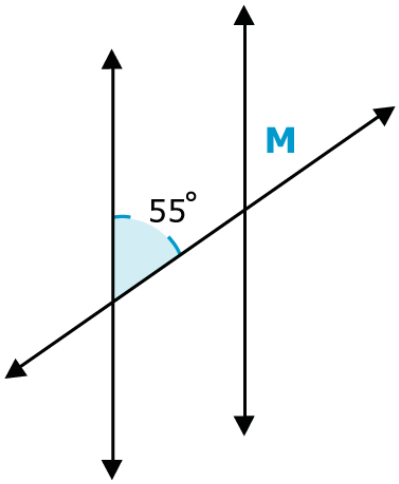
15. Two angles with different measures whose sum is 180°.

Directions: Find the measure of the unknown angle.

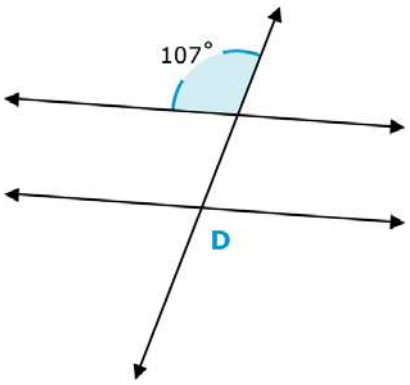
16.



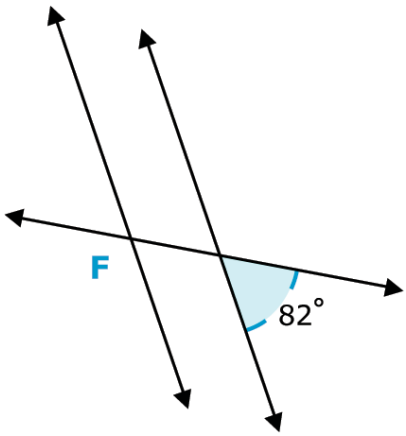
17.



18.



19.



20.