More on Angles:
Vertical, Corresponding, and Alternate Interior and Exterior

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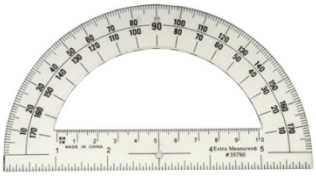
Summary: Describes vertical and corresponding angles. Describes alternate interior and exterior angles.
Learning Objectives: To define vertical, corresponding, alternate interior, and alternate exterior angles.



A protractor is a tool used to measure unknown angles. A protractor is very useful when you need to find one angle at a time, but if you need to find a lot of different adjacent angles, it's possible to determine their measures algebraically, rather than measuring each angle individually with a protractor.

Understanding the properties of vertical, corresponding, alternate interior, and exterior angles helps us find the measures of several angles quickly.

In this handout, we assume that you're already familiar with terminology related to angles. Review the Academic Center handouts *Understanding Angles* and *Complementary and Supplementary Angles*.

What Are Vertical Angles?

Vertical angles are formed when two lines intersect and have the same degree measurement.

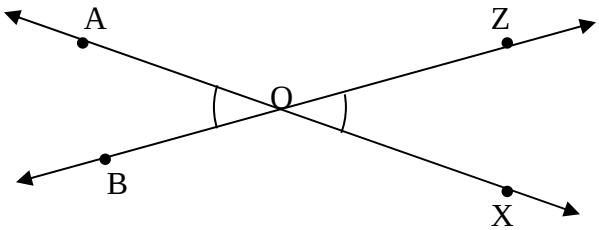
$m\angle AOB = m\angle XOZ$

Other ways to write this:

$m\angle AOB = m\angle ZOX$

$m\angle BOA = m\angle XOZ$

$m\angle BOA = m\angle ZOX$



The "$m\angle$" represents "measure of angle", and the above formula reads "the measure of angle AOB equals the measure of angle XOZ."

In the diagram above, ∠AOB and ∠XOZ are vertical angles of each other because they are on opposite sides of a shared vertex.

We are not given any degree measurements in the diagram, but we don't need to know the values of vertical angles to know that they are equal. If we used a protractor to measure the angles of just one angle, we could easily find the remaining values by the definitions of vertical and supplementary angles.

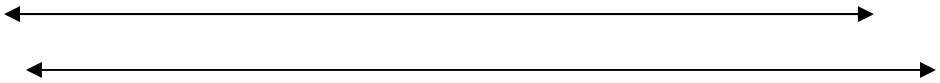
There is also a different pair of vertical angles in the diagram above. Can you spot them?

Answer: ∠AOZ and ∠BOX are vertical angles of each other.

What Are Corresponding Angles?

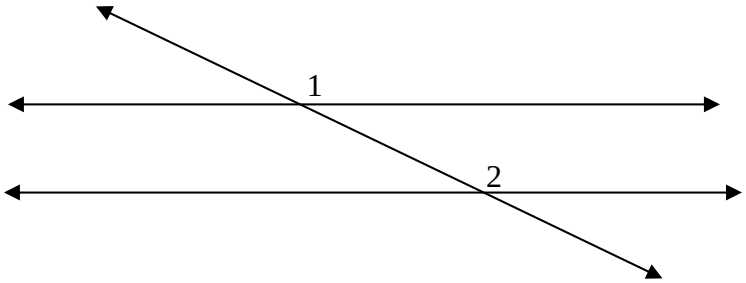
Corresponding angles are formed when a line intersects two parallel lines.

Parallel lines are lines on the same plane that **never intersect** when they are extended infinitely in both directions.



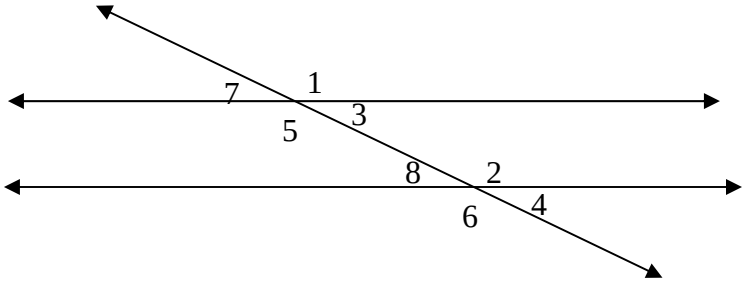
The diagram below shows what happens when a line interests two parallel lines. Corresponding angles are created, and, in this case, ∠1 and ∠2 are **corresponding angles**. They share the same exact degree measurement.

$m\angle 1 = m\angle 2$



Let's say that $m\angle 1 = 155°$, then by the definition of corresponding angles, $m\angle 2 = 155°$.

Also, when a line intersects two parallel lines, four pairs of corresponding angles are formed. In the diagram above, there are also 3 other pairs of corresponding angles. Can you find them?



Pairs of corresponding angles:

$m\angle 1 = m\angle 3$ $\quad$ $m\angle 3 = m\angle 4$

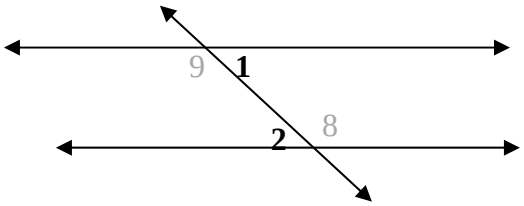
$m\angle 5 = m\angle 6$ $\quad$ $m\angle 7 = m\angle 8$

What Are Alternate Interior Angles and Alternate Exterior Angles?

Alternate interior angles are formed when a line intersects a pair of parallel lines, such as in the diagram below. ∠1 and ∠2 are **alternate interior angles**. They have the same degree measurement.

$m\angle 1 = m\angle 2$

Likewise,
$m\angle 9 = m\angle 8$

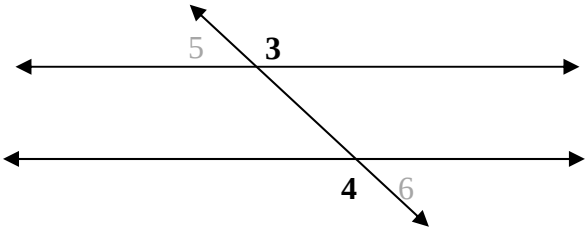


Angles 1 and 2 are on the inside of the parallel lines and are alternates of each other. Notice that they do not share the same vertex like vertical angles.

Alternate exterior angles are formed when a line intersects two parallel lines, such as in the next diagram. ∠3 and ∠4 are called **alternate exterior angles**, and alternate exterior angles share the same degree measurement.

$m\angle 3 = m\angle 4$

Likewise,
$m\angle 6 = m\angle 5$



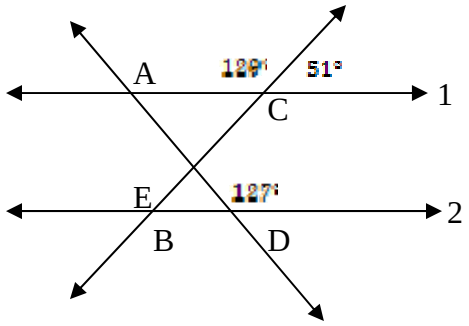
Angles 3 and 4 are on the outside of the parallel lines and are alternates of each other.

Please note that when a straight line intersects two parallel lines, there are 2 pairs of alternate interior angles and 2 pairs of alternate exterior angles.

See an example on the next page.

Example

In this example, we will apply what we've learned. Find the measurements for angles A, B, C, D, and E. Assume lines 1 and 2 are parallel.



Let's start with ∠C. On the opposite side of the vertex is an angle measuring 129°. These are **vertical angles**; therefore, m∠C = 129°.

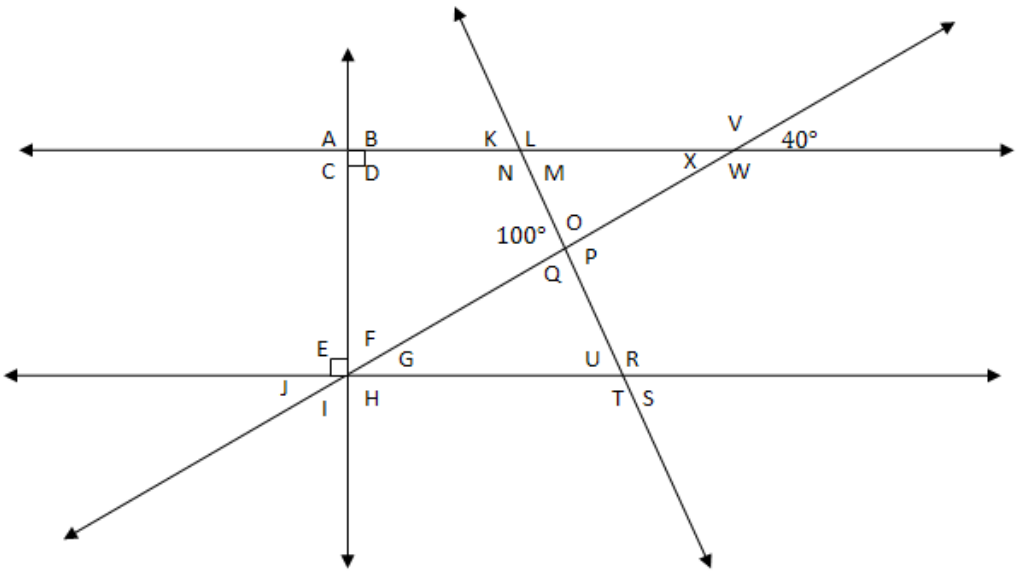
∠C and ∠B are **corresponding angles**,
and ∠C and ∠E are **alternate interior angles**,
and ∠B and ∠E are **vertical angles**,
therefore, m∠C = m∠B = m∠E = 129°

Let's move on to ∠A. The angle **corresponding** with ∠A measures 127°; therefore, m∠A = 127°. Lastly, ∠D is adjacent to the angle measuring 127°, and together they create a straight line. This makes them supplementary angles (which is covered in more detail in another handout), so their measurements should add up to 180°. Therefore, $m\angle D = (180° - 127°) = 53°$.

Practice Exercise

Find the measurements of the remaining angles. Assume the two horizontal lines are parallel.

Hint: Three angles inside a triangle always add up to 180°.



Answers

$m\angle A = 90°$	$m\angle E = 90°$	$m\angle K = 60°$	$m\angle O = 80°$	$m\angle R = 120°$	$m\angle V = 140°$
$m\angle B = 90°$	$m\angle F = 50°$	$m\angle L = 120°$	$m\angle P = 100°$	$m\angle S = 60°$	$m\angle W = 140°$
$m\angle C = 90°$	$m\angle G = 40°$	$m\angle M = 60°$	$m\angle Q = 80°$	$m\angle T = 120°$	$m\angle X = 40°$
$m\angle D = 90°$	$m\angle H = 90°$	$m\angle N = 120°$		$m\angle U = 60°$	
	$m\angle I = 50°$				
	$m\angle J = 40°$				