

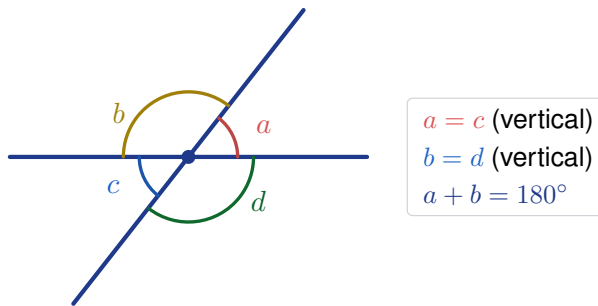
# Adjacent, Vertical, and Linear Pair Angles

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Score: \_\_\_\_\_ / 17

When two lines cross, they create four angles—and those angles are not random! **Adjacent angles** share a side, **vertical angles** sit across from each other and are always equal, and **linear pairs** form a straight line and add to  $180^\circ$ . Once you spot these patterns, you can find missing angles without ever picking up a protractor. This topic trains your eye to see structure instead of just shapes!



## Key Concepts & Quick Review

**Vertical angles:**  $a = c$  and  $b = d$ . They are always *congruent*.

**Linear pair:**  $a + b = 180^\circ$  (angles on a straight line).

**Adjacent angles:** share a vertex and a common ray; no overlap.

## Examples

① Two lines intersect. One angle measures  $63^\circ$ . Find the other three angles.

**Think It Through:** When two lines cross, the opposite angles are called vertical angles, and they are always equal. So the angle across from  $63^\circ$  is also  $63^\circ$ . The two angles beside  $63^\circ$  form linear pairs with it, so each must add with  $63^\circ$  to make  $180^\circ$ . That gives  $180^\circ - 63^\circ = 117^\circ$ . So the four angles are  $63^\circ$ ,  $117^\circ$ ,  $63^\circ$ , and  $117^\circ$ .

**Answer:**  $63^\circ$ ,  $117^\circ$ ,  $63^\circ$ ,  $117^\circ$

② A road crosses a rail track. The acute angle between them is  $(3x + 9)^\circ$  and its vertical angle is  $(5x - 7)^\circ$ . Find  $x$  and all four angles.

**Think It Through:** Because the labeled angles are vertical angles, they must be equal. Set up the equation  $3x + 9 = 5x - 7$ . Solving gives  $16 = 2x$ , so  $x = 8$ . Substitute back into either expression to find the acute angle:  $3(8) + 9 = 33^\circ$ . The angles next to it are linear pairs, so each is  $180^\circ - 33^\circ = 147^\circ$ . The four angles around the intersection are  $33^\circ$ ,  $147^\circ$ ,  $33^\circ$ ,  $147^\circ$ .

**Answer:**  $x = 8$ ; angles:  $33^\circ$ ,  $147^\circ$ ,  $33^\circ$ ,  $147^\circ$






### Practice Problems

Find the missing angle(s) using vertical angle and linear pair relationships.

1. Two angles form a linear pair. One angle is  $45^\circ$ . Find the other angle. \_\_\_\_\_
2. Two angles are vertical angles. One angle is  $72^\circ$ . Find the other angle. \_\_\_\_\_
3. Two angles form a linear pair. One angle is  $118^\circ$ . Find the other angle. \_\_\_\_\_
4. Two angles are vertical angles. One angle is  $155^\circ$ . Find the other angle. \_\_\_\_\_
5. Two lines intersect. One angle is  $90^\circ$ . Find all four angle measures. \_\_\_\_\_
6. Two angles form a linear pair:  $(2x + 10)^\circ$  and  $70^\circ$ . Find  $x$ . \_\_\_\_\_
7. Two vertical angles measure  $(4x)^\circ$  and  $(3x + 15)^\circ$ . Find  $x$ . \_\_\_\_\_
8. Two angles form a linear pair:  $(5x - 5)^\circ$  and  $(3x + 11)^\circ$ . Find  $x$  and both angle measures. \_\_\_\_\_
9. Two lines intersect. One angle is  $38^\circ$ . Find all four angle measures. \_\_\_\_\_
10. Two vertical angles measure  $(7x - 3)^\circ$  and  $(5x + 13)^\circ$ . Find each angle measure. \_\_\_\_\_
11. Two equal angles form a linear pair. Find the measure of each angle. \_\_\_\_\_
12. Two vertical angles measure  $(x + 40)^\circ$  and  $(3x)^\circ$ . Find  $x$ . \_\_\_\_\_
13. Two lines intersect. One angle is  $127^\circ$ . Find all four angle measures. \_\_\_\_\_
14. Two angles form a linear pair:  $2(x + 10)^\circ$  and  $(x + 20)^\circ$ . Find  $x$ . \_\_\_\_\_
15. Two vertical angles measure  $(8 - 2x)^\circ$  and  $(2 + 4x)^\circ$ . Find each angle measure. \_\_\_\_\_

### Study Tips

-  **Vertical = equal.** Set the two expressions equal and solve for the variable.
-  **Linear pair = sum to  $180^\circ$ .** Add the expressions and set equal to 180.
-  Always sketch the intersecting lines and label the four regions — it takes 10 s and prevents all confusion.

### Word Problems

16. Two straight hiking trails intersect at a clearing. Rangers mark one of the four angles as  $(4x + 12)^\circ$  and its vertical angle as  $(6x - 8)^\circ$ . Find  $x$ , the measure of all four angles, and identify which angles are linear pairs with each other. \_\_\_\_\_
17. A carpenter's two pieces of trim cross to form an X-shape on a wall. One angle of the X is  $(2y - 5)^\circ$  and the next adjacent angle is  $(y + 20)^\circ$ . Since they form a linear pair, find  $y$  and all four angles. If the carpenter wants the X to be symmetric (all four angles equal), what must each angle be, and is that possible with straight trim pieces? \_\_\_\_\_



## Answer Keys

- |  |  |
|--|--|
| <p>1) <math>135^\circ</math><br/>           2) <math>72^\circ</math><br/>           3) <math>62^\circ</math><br/>           4) <math>155^\circ</math><br/>           5) <math>90^\circ</math> each<br/>           6) 50<br/>           7) 15<br/>           8) <math>x = \frac{87}{4}</math>; angles <math>103.75^\circ, 76.25^\circ</math><br/>           9) <math>38^\circ, 142^\circ, 38^\circ, 142^\circ</math><br/>           10) <math>53^\circ</math></p> | <p>11) <math>90^\circ</math> each<br/>           12) 20<br/>           13) <math>127^\circ, 53^\circ, 127^\circ, 53^\circ</math><br/>           14) <math>\frac{140}{3}</math><br/>           15) <math>6^\circ</math><br/>           16) <math>x = 10</math>; angles <math>52^\circ, 128^\circ, 52^\circ, 128^\circ</math>; linear pairs (<math>52^\circ, 128^\circ</math>)<br/>           17) <math>y = 55</math>; angles <math>105^\circ, 75^\circ, 105^\circ, 75^\circ</math>; symmetric X only at <math>90^\circ</math></p> |
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### Step-by-Step Explanations

**Strategy:** For Writing and Evaluating Algebraic Expressions, read the expression by its parts, combining like terms, distributing only when needed, and substituting values after simplifying. A quick expression check is to substitute only after the expression has been simplified.

**Practice 1:** Evaluate  $3x + 5$  when  $x = 4$ . **Answer:** 17

At the beginning of the practice, substitute the value and follow the order of operations before simplifying.

**Practice 15:** Evaluate  $7m - 4$  when  $m = \frac{1}{2}$ . **Answer:**  $-\frac{1}{2}$

For the second model problem, write the expression first, then evaluate it for the given input.

**Word-problem notes:**

**16. Answer:**  $C = 3.50t + 1.25$ ; 8 tacos: \$29.25;  $18.75 = 3.50t + 1.25 \Rightarrow t = 5$  tacos.

The total cost has two parts: the taco cost and the one-time guacamole fee. That is why the expression is  $C = 3.50t + 1.25$ . For 8 tacos, substitute  $t = 8$ :  $C = 3.50(8) + 1.25 = 28 + 1.25 = 29.25$ . For the second group, solve  $3.50t + 1.25 = 18.75$ . Subtract 1.25 first to get  $3.50t = 17.50$ , then divide by 3.50. That gives  $t = 5$ , so they ordered 5 tacos.

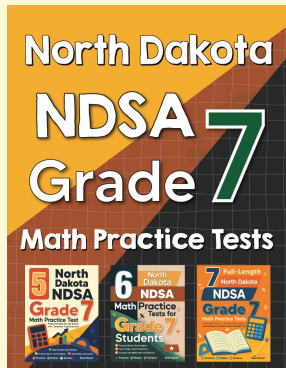
**17. Answer:** After 3 s: 84 m; after 5 s: 20 m; drops below 30 m between  $t = 4$  and  $t = 5$ .

Use the formula by substituting the time values. At  $t = 3$ ,  $h = 120 - 4(3)^2 = 120 - 4(9) = 120 - 36 = 84$  m. At  $t = 5$ ,  $h = 120 - 4(5)^2 = 120 - 4(25) = 120 - 100 = 20$  m. To figure out when it first drops below 30 m, test the nearby whole-number times. At  $t = 4$ , the height is  $120 - 4(16) = 56$  m, which is still above 30. At  $t = 5$ , it is already below, so the drop below 30 happens between 4 and 5 s.



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