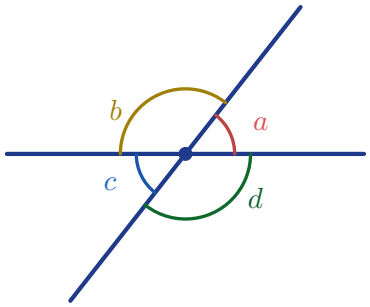
# Adjacent, Vertical, and Linear Pair Angles

| 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 $180°$. 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!




$a = c$ (vertical)
$b = d$ (vertical)
$a + b = 180°$

## Key Concepts & Quick Review

**Vertical angles:** $a = c$ and $b = d$. They are always *congruent*.
**Linear pair:** $a + b = 180°$ (angles on a straight line).
**Adjacent angles:** share a vertex and a common ray; no overlap.

## Examples

① Two lines intersect. One angle measures $63°$. 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 $63°$ is also $63°$. The two angles beside $63°$ form linear pairs with it, so each must add with $63°$ to make $180°$. That gives $180° - 63° = 117°$. So the four angles are $63°$, $117°$, $63°$, and $117°$.

**Answer:** $63°,\ 117°,\ 63°,\ 117°$

② A road crosses a rail track. The acute angle between them is $(3x + 9)°$ and its vertical angle is $(5x - 7)°$. 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: $3(8) + 9 = 33°$. The angles next to it are linear pairs, so each is $180° - 33° = 147°$. The four angles around the intersection are $33°, 147°, 33°, 147°$.

**Answer:** $x = 8$; *angles:* $33°, 147°, 33°, 147°$

## Practice Problems

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

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

### Study Tips

- **Vertical** $=$ **equal**. Set the two expressions equal and solve for the variable.
- **Linear pair** $=$ **sum to** $180°$. 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 $(4x + 12)°$ and its vertical angle as $(6x - 8)°$. 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 $(2y - 5)°$ and the next adjacent angle is $(y + 20)°$. 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

**1)** $135°$
**2)** $72°$
**3)** $62°$
**4)** $155°$
**5)** $90°$ each
**6)** 50
**7)** 15
**8)** $x = \frac{87}{4}$; angles $103.75°, 76.25°$
**9)** $38°, 142°, 38°, 142°$
**10)** $53°$
**11)** $90°$ each
**12)** 20
**13)** $127°, 53°, 127°, 53°$
**14)** $\frac{140}{3}$
**15)** $6°$
**16)** $x = 10$; angles $52°, 128°, 52°, 128°$; linear pairs $(52°, 128°)$
**17)** $y = 55$; angles $105°, 75°, 105°, 75°$; symmetric X only at $90°$

## 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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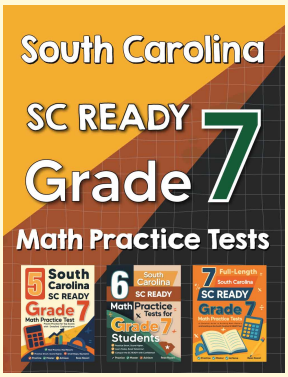


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