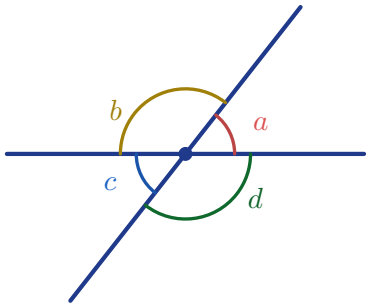
Adjacent, Vertical, and Linear Pair Angles

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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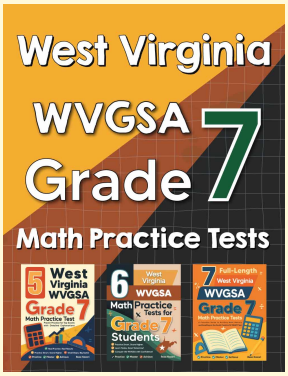

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