

4-4 Parallel and Perpendicular Lines

Write an equation in slope-intercept form for the line that passes through the given point and is parallel to the graph of the given equation.

1. $(-1, 2), y = \frac{1}{2}x - 3$

SOLUTION:

The slope of the line with equation $y = \frac{1}{2}x - 3$ is $\frac{1}{2}$. The line parallel to $y = \frac{1}{2}x - 3$ has the same slope, $\frac{1}{2}$.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 2 = \frac{1}{2}[x - (-1)] \quad \text{Substitute.}$$

$$y - 2 = \frac{1}{2}[x + 1] \quad \text{Simplify.}$$

$$y - 2 = \frac{1}{2}x + \frac{1}{2} \quad \text{Distributive Property}$$

$$y - 2 + 2 = \frac{1}{2}x + \frac{1}{2} + 2 \quad \text{Add 2 to each side.}$$

$$y = \frac{1}{2}x + 2\frac{1}{2} \quad \text{Simplify.}$$

2. $(0, 4), y = -4x + 5$

SOLUTION:

The slope of the line with equation $y = -4x + 5$ is -4 . The line parallel to $y = -4x + 5$ has the same slope, -4 .

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 4 = -4(x - 0) \quad \text{Substitute.}$$

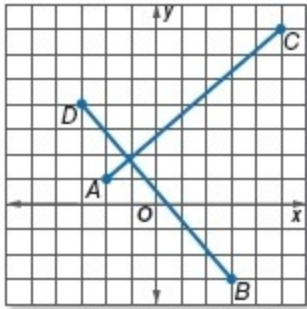
$$y - 4 = -4x + 0 \quad \text{Distributive Property}$$

$$y - 4 + 4 = -4x + 0 + 4 \quad \text{Add 4 to each side.}$$

$$y = -4x + 4 \quad \text{Simplify.}$$

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3. **GARDENS** A garden is in the shape of a quadrilateral with vertices $A(-2, 1)$, $B(3, -3)$, $C(5, 7)$, and $D(-3, 4)$. Two paths represented by \overline{AC} and \overline{BD} cut across the garden. Are the paths perpendicular? Explain.



SOLUTION:

Find the slope of \overline{AC} .

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{1 - 7}{-2 - 5} \\ &= \frac{-6}{-7} \\ &= \frac{6}{7} \end{aligned}$$

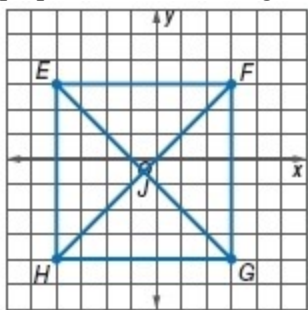
Find the slope of \overline{BD} .

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-3 - 4}{3 - (-3)} \\ &= -\frac{7}{6} \end{aligned}$$

The slope of \overline{BD} is the opposite reciprocal of the slope of \overline{AC} , so the two paths are perpendicular.

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4. **CCSS PRECISION** A square is a quadrilateral that has opposite sides parallel, consecutive sides that are perpendicular, and diagonals that are perpendicular. Determine whether the quadrilateral is a square. Explain.



SOLUTION:

Sides \overline{EH} and \overline{FG} are both vertical line segments and have undefined slopes, so they are parallel. Sides \overline{EF} and \overline{HG} are both horizontal line segments and have a slope of 0, so they are parallel.

Side \overline{EG} has a slope of -1 (down 1 unit, right 1 unit). Side \overline{FH} has a slope of 1 (up 1 unit, right 1 unit). Since the slopes of \overline{EG} and \overline{FH} are opposite reciprocals, they are perpendicular. The quadrilateral is a square.

Determine whether the graphs of the following equations are *parallel* or *perpendicular*. Explain.

5. $y = -2x$, $2y = x$, $4y = 2x + 4$

SOLUTION:

The slope of the first equation is -2 . Write the second two equations in slope-intercept form.

$$2y = x$$

$$\frac{2y}{2} = \frac{x}{2}$$

$$y = \frac{1}{2}x$$

The slope of the second equation is $\frac{1}{2}$.

$$4y = 2x + 4$$

$$\frac{4y}{4} = \frac{2x + 4}{4}$$

$$y = \frac{1}{2}x + 1$$

The slope of the third equation is $\frac{1}{2}$.

The slope of $y = -2x$ is the opposite reciprocal of the slope of $2y = x$ and $4y = 2x + 4$, so it is perpendicular to the other two graphs. And, the slopes of $2y = x$ and $4y = 2x + 4$ are equal, so they are parallel.

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6. $y = \frac{1}{2}x$, $3y = x$, $y = -\frac{1}{2}x$

SOLUTION:

The slope of the first equation is $\frac{1}{2}$. Write the second equation in slope-intercept form.

$$3y = x$$

$$\frac{3y}{3} = \frac{x}{3}$$

$$y = \frac{1}{3}x$$

The slope of the second equation is $\frac{1}{3}$. The slope of the third equation is $-\frac{1}{2}$.

None of the slopes are equal or opposite reciprocals, so none of the graphs of the equations are parallel or perpendicular.

Write an equation in slope-intercept form for the line that passes through the given point and is perpendicular to the graph of the equation.

7. $(-2, 3)$, $y = -\frac{1}{2}x - 4$

SOLUTION:

The slope of the line with equation $y = -\frac{1}{2}x - 4$ is $-\frac{1}{2}$. The slope of the perpendicular line is the opposite reciprocal of $-\frac{1}{2}$, or 2.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 3 = 2[x - (-2)] \quad \text{Substitute.}$$

$$y - 3 = 2[x + 2] \quad \text{Simplify.}$$

$$y - 3 = 2x + 4 \quad \text{Distributive Property}$$

$$y - 3 + 3 = 2x + 4 + 3 \quad \text{Add 3 to each side.}$$

$$y = 2x + 7 \quad \text{Simplify.}$$

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8. $(-1, 4), y = 3x + 5$

SOLUTION:

The slope of the line with equation $y = 3x + 5$ is 3. The slope of the perpendicular line is the opposite reciprocal of 3, or $-\frac{1}{3}$.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 4 = -\frac{1}{3}[x - (-1)] \quad \text{Substitute.}$$

$$y - 4 = -\frac{1}{3}[x + 1] \quad \text{Simplify.}$$

$$y - 4 = -\frac{1}{3}x - \frac{1}{3} \quad \text{Distributive Property}$$

$$y - 4 + 4 = -\frac{1}{3}x - \frac{1}{3} + 4 \quad \text{Add 4 to each side.}$$

$$y = -\frac{1}{3}x + 3\frac{2}{3} \quad \text{Simplify.}$$

9. $(2, 3), 2x + 3y = 4$

SOLUTION:

Write the equation in slope-intercept form.

$$2x + 3y = 4 \quad \text{Original equation}$$

$$2 - 2x + 3y = 4 - 2x \quad \text{Subtract } 2x \text{ from each side.}$$

$$3y = -2x + 4 \quad \text{Simplify.}$$

$$\frac{3y}{3} = \frac{-2x+4}{3} \quad \text{Divide each side by 3.}$$

$$y = -\frac{2}{3}x + 1\frac{1}{3} \quad \text{Simplify.}$$

The slope of the line with equation $2x + 3y = 4$ is $-\frac{2}{3}$. The slope of the perpendicular line is the opposite reciprocal of $-\frac{2}{3}$, or $\frac{3}{2}$.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 3 = \frac{3}{2}(x - 2) \quad \text{Substitute.}$$

$$y - 3 = \frac{3}{2}x - 3 \quad \text{Distributive Property}$$

$$y - 3 + 3 = \frac{3}{2}x - 3 + 3 \quad \text{Add 3 to each side.}$$

$$y = \frac{3}{2}x \quad \text{Simplify.}$$

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10. $(3, 6), 3x - 4y = -2$

SOLUTION:

Write the equation in slope-intercept form.

$$3x - 4y = -2 \quad \text{Original equation}$$

$$3x - 3x - 4y = -2 - 3x \quad \text{Subtract } 3x \text{ from each side.}$$

$$-4y = -3x - 2 \quad \text{Simplify.}$$

$$\frac{-4y}{-4} = \frac{-3x-2}{-4} \quad \text{Divide each side by } -4.$$

$$y = \frac{3}{4}x + \frac{1}{2} \quad \text{Simplify.}$$

The slope of the line with equation $3x - 4y = -2$ is $\frac{3}{4}$. The slope of the perpendicular line is the opposite reciprocal of $\frac{3}{4}$, or $-\frac{4}{3}$.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 6 = -\frac{4}{3}(x - 3) \quad \text{Substitute.}$$

$$y - 6 = -\frac{4}{3}x + 4 \quad \text{Distributive Property}$$

$$y - 6 + 6 = -\frac{4}{3}x + 4 - 6 \quad \text{Add 6 to each side.}$$

$$y = -\frac{4}{3}x + 10 \quad \text{Simplify.}$$

Write an equation in slope-intercept form for the line that passes through the given point and is parallel to the graph of given equation.

11. $(3, -2), y = x + 4$

SOLUTION:

The slope of the line with equation $y = x + 4$ is 1. The line parallel to $y = x + 4$ has the same slope, 1.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - (-2) = 1(x - 3) \quad \text{Substitute.}$$

$$y + 2 = x - 3 \quad \text{Simplify.}$$

$$y + 2 - 2 = x - 3 - 2 \quad \text{Subtract.}$$

$$y = x - 5 \quad \text{Simplify.}$$

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12. $(4, -3), y = 3x - 5$

SOLUTION:

The slope of the line with equation $y = 3x - 5$ is 3. The line parallel to $y = 3x - 5$ has the same slope, 3.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - (-3) = 3(x - 4) \quad \text{Substitute.}$$

$$y - (-3) = 3x - 12 \quad \text{Distributive Property}$$

$$y + 3 = 3x - 12 \quad \text{Simplify.}$$

$$y - 3 + 3 = 3x - 12 - 3 \quad \text{Subtract.}$$

$$y = 3x - 15 \quad \text{Simplify.}$$

13. $(0, 2), y = -5x + 8$

SOLUTION:

The slope of the line with equation $y = -5x + 8$ is -5 . The line parallel to $y = -5x + 8$ has the same slope, -5 .

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 2 = -5(x - 0) \quad \text{Substitute.}$$

$$y - 2 = -5x + 0 \quad \text{Distributive Property}$$

$$y - 2 + 2 = -5x + 0 + 2 \quad \text{Add 2 to each side.}$$

$$y = -5x + 2 \quad \text{Simplify.}$$

14. $(-4, 2), y = -\frac{1}{2}x + 6$

SOLUTION:

The slope of the line with equation $y = -\frac{1}{2}x + 6$ is $-\frac{1}{2}$. The line parallel to $y = -\frac{1}{2}x + 6$ has the same slope, $-\frac{1}{2}$.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 2 = -\frac{1}{2}[x - (-4)] \quad \text{Substitute.}$$

$$y - 2 = -\frac{1}{2}[x + 4] \quad \text{Simplify.}$$

$$y - 2 = -\frac{1}{2}x - 2 \quad \text{Distributive Property}$$

$$y - 2 + 2 = -\frac{1}{2}x - 2 + 2 \quad \text{Add 2 to each side}$$

$$y = -\frac{1}{2}x \quad \text{Simplify.}$$

4-4 Parallel and Perpendicular Lines

15. $(-2, 3), y = -\frac{3}{4}x + 4$

SOLUTION:

The slope of the line with equation $y = -\frac{3}{4}x + 4$ is $-\frac{3}{4}$. The line parallel to $y = -\frac{3}{4}x + 4$ has the same slope, $-\frac{3}{4}$. Use the point-slope form formula to find the equation for the parallel line.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 3 = -\frac{3}{4}[x - (-2)] \quad \text{Substitute.}$$

$$y - 3 = -\frac{3}{4}[x + 2] \quad \text{Simplify.}$$

$$y - 3 = -\frac{3}{4}x - \frac{3}{2} \quad \text{Distributive property}$$

$$y - 3 + 3 = -\frac{3}{4}x - \frac{3}{2} + 3 \quad \text{Add 3 to each side}$$

$$y = -\frac{3}{4}x + 1\frac{1}{2} \quad \text{Simplify.}$$

16. $(9, 12), y = 13x - 4$

SOLUTION:

The slope of the line with equation $y = 13x - 4$ is 13. The line parallel to $y = 13x - 4$ has the same slope, 13.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

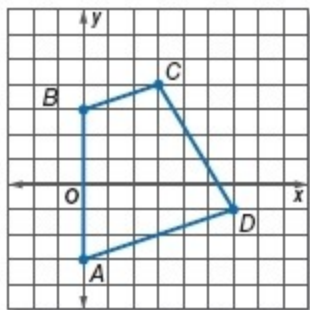
$$y - 12 = 13(x - 9) \quad \text{Substitute.}$$

$$y - 12 = 13x - 117 \quad \text{Distributive Property}$$

$$y - 12 + 12 = 13x - 117 + 12 \quad \text{Add 12 to each side.}$$

$$y = 13x - 105 \quad \text{Simplify.}$$

17. **GEOMETRY** A trapezoid is a quadrilateral that has exactly one pair of parallel opposite sides. Is $ABCD$ a trapezoid? Explain.

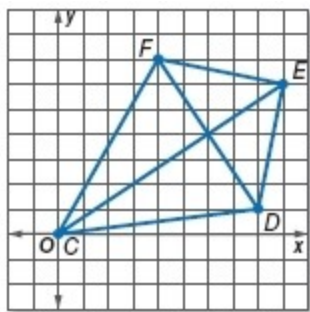


SOLUTION:

Use the graph to determine the slope of each segment of the quadrilateral. The line containing \overline{AD} and the line containing \overline{BC} have the same slope, $\frac{1}{3}$ (up 1 unit, right 3 units). Therefore one pair of sides is parallel. The slope of \overline{AB} is undefined and the slope of \overline{CD} is $-\frac{5}{3}$, so they are not parallel. $ABCD$ is a trapezoid.

4-4 Parallel and Perpendicular Lines

18. **GEOMETRY** $CDEF$ is a kite. Are the diagonals of the kite perpendicular? Explain your reasoning.



SOLUTION:

Use the graph to determine the slope of each diagonal. The slope of \overline{CE} is $\frac{2}{3}$ (up 2 units, right 3 units) and the slope of \overline{DF} is $-\frac{3}{2}$ (down 3 units, right 2 units). The diagonals are perpendicular because the slopes are opposite reciprocals.

19. Determine whether the graphs of $y = -6x + 4$ and $y = \frac{1}{6}x$ are perpendicular. Explain.

SOLUTION:

The slope of $y = -6x + 4$ is -6 . The slope of $y = \frac{1}{6}x$ is $\frac{1}{6}$. The slopes are opposite reciprocals, so $y = -6x + 4$ and $y = \frac{1}{6}x$ are perpendicular.

4-4 Parallel and Perpendicular Lines

20. **MAPS** On a map, Elmwood Drive passes through $R(4, -11)$ and $S(0, -9)$, and Taylor Road passes through $J(6, -2)$ and $K(4, -5)$. If they are straight lines, are the two streets perpendicular? Explain.

SOLUTION:

Find the slope of Elmwood Drive (\overline{RS}).

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-9 - (-11)}{0 - 4} \\ &= \frac{2}{-4} \\ &= -\frac{1}{2} \end{aligned}$$

Find the slope of Taylor Road (\overline{JK}).

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-5 - (-2)}{4 - 6} \\ &= \frac{-3}{-2} \\ &= \frac{3}{2} \end{aligned}$$

The two streets are not perpendicular because their slopes are not opposite reciprocals.

4-4 Parallel and Perpendicular Lines

CCSS PERSEVERANCE Determine whether the graphs of the following equations are *parallel* or *perpendicular*. Explain.

21. $2x - 8y = -24$, $4x + y = -2$, $x - 4y = 4$

SOLUTION:

Write the equations in slope-intercept form.

Equation 1:

$$2x - 8y = -24 \quad \text{Original equation 1}$$

$$2x - 2x - 8y = -24 - 2x \quad \text{Subtract } 2x \text{ from each side.}$$

$$-8y = -2x - 24 \quad \text{Simplify.}$$

$$\frac{-8y}{-8} = \frac{-2x - 24}{-8} \quad \text{Divide each side by } -8.$$

$$y = \frac{1}{4}x + 3 \quad \text{Simplify.}$$

The slope of $2x - 8y = -24$ is $\frac{1}{4}$.

Equation 2:

$$4x + y = -2 \quad \text{Original equation 2}$$

$$4x - 4x + y = -2 - 4x \quad \text{Subtract } 4x \text{ from each side.}$$

$$y = -4x - 2 \quad \text{Simplify.}$$

The slope of $4x + y = -2$ is -4 .

Equation 3:

$$x - 4y = 4 \quad \text{Original equation 3}$$

$$x - x - 4y = 4 - x \quad \text{Subtract } x \text{ from each side.}$$

$$-4y = -x + 4 \quad \text{Simplify.}$$

$$\frac{-4y}{-4} = \frac{-x + 4}{-4} \quad \text{Divide each side by } -4.$$

$$y = \frac{1}{4}x - 1 \quad \text{Simplify.}$$

The slope of $x - 4y = 4$ is $\frac{1}{4}$.

The slope of $4x + y = -2$ is the opposite reciprocal of the slope of $2x - 8y = -24$ and $x - 4y = 4$, so it is perpendicular to the other two graphs. And, the slopes of $2x - 8y = -24$ and $x - 4y = 4$ are equal, so they are parallel.

4-4 Parallel and Perpendicular Lines

22. $3x - 9y = 9$, $3y = x + 12$, $2x - 6y = 12$

SOLUTION:

Write the equations in slope-intercept form.

Equation 1:

$$3x - 9y = 9 \quad \text{Original equation 1}$$

$$3x - 3x - 9y = 9 - 3x \quad \text{Subtract } 3x \text{ from each side.}$$

$$-9y = -3x + 9 \quad \text{Simplify.}$$

$$\frac{-9y}{-9} = \frac{-3x+9}{-9} \quad \text{Divide each side by } -9.$$

$$y = \frac{1}{3}x - 1 \quad \text{Simplify.}$$

The slope of $3x - 9y = 9$ is $\frac{1}{3}$.

Equation 2:

$$3y = x + 12 \quad \text{Original equation 2}$$

$$\frac{3y}{3} = \frac{x+12}{3} \quad \text{Divide each side by 3.}$$

$$y = \frac{1}{3}x + 4 \quad \text{Simplify.}$$

The slope of $3y = x + 12$ is $\frac{1}{3}$.

Equation 3:

$$2x - 6y = 12 \quad \text{Original equation 3}$$

$$2x - 2x - 6y = 12 - 2x \quad \text{Subtract } 2x \text{ from each side.}$$

$$-6y = -2x + 12 \quad \text{Simplify.}$$

$$\frac{-6y}{-6} = \frac{-2x+12}{-6} \quad \text{Divide each side by 6.}$$

$$y = \frac{1}{3}x - 2 \quad \text{Simplify.}$$

The slope of $2x - 6y = 12$ is $\frac{1}{3}$.

The slopes of $3x - 9y = 9$, $3y = x + 12$, and $2x - 6y = 12$ are all equal, so they are all parallel.

4-4 Parallel and Perpendicular Lines

Write an equation in slope-intercept form for the line that passes through the given point and is perpendicular to the graph of the equation.

23. $(-3, -2), y = -2x + 4$

SOLUTION:

The slope of the line with equation $y = -2x + 4$ is -2 . The slope of the perpendicular line is the opposite reciprocal of -2 , or $\frac{1}{2}$.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - (-2) = \frac{1}{2}[x - (-3)] \quad \text{Substitute.}$$

$$y + 2 = \frac{1}{2}[x + 3] \quad \text{Simplify.}$$

$$y + 2 = \frac{1}{2}x + \frac{3}{2} \quad \text{Distributive Property}$$

$$y + 2 - 2 = \frac{1}{2}x + \frac{3}{2} - 2 \quad \text{Subtract.}$$

$$y = \frac{1}{2}x - \frac{1}{2} \quad \text{Simplify.}$$

24. $(-5, 2), y = \frac{1}{2}x - 3$

SOLUTION:

The slope of the line with equation $y = \frac{1}{2}x - 3$ is $\frac{1}{2}$. The slope of the perpendicular line is the opposite reciprocal of $\frac{1}{2}$, or -2 .

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 2 = -2[x - (-5)] \quad \text{Substitute.}$$

$$y - 2 = -[x + 5] \quad \text{Simplify.}$$

$$y - 2 = -2x - 10 \quad \text{Distributive Property}$$

$$y - 2 + 2 = -2x - 10 + 2 \quad \text{Add 2 to each side.}$$

$$y = -2x - 8 \quad \text{Simplify.}$$

4-4 Parallel and Perpendicular Lines

25. $(-4, 5), y = \frac{1}{3}x + 6$

SOLUTION:

The slope of the line with equation $y = \frac{1}{3}x + 6$ is $\frac{1}{3}$. The slope of the perpendicular line is the opposite reciprocal of $\frac{1}{3}$, or -3 .

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 5 = -3[x - (-4)] \quad \text{Substitute.}$$

$$y - 5 = -3[x + 4] \quad \text{Simplify.}$$

$$y - 5 = -3x - 12 \quad \text{Distributive Property}$$

$$y - 5 + 5 = -3x - 12 + 5 \quad \text{Add 5 to each side.}$$

$$y = -3x - 7 \quad \text{Simplify.}$$

26. $(2, 6), y = -\frac{1}{4}x + 3$

SOLUTION:

The slope of the line with equation $y = -\frac{1}{4}x + 3$ is $-\frac{1}{4}$. The slope of the perpendicular line is the opposite reciprocal of $-\frac{1}{4}$, or 4.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 6 = 4(x - 2) \quad \text{Substitute.}$$

$$y - 6 = 4x - 8 \quad \text{Distributive Property}$$

$$y - 6 + 6 = 4x - 8 + 6 \quad \text{Add 6 to each side.}$$

$$y = 4x - 2 \quad \text{Simplify.}$$

27. $(3, 8), y = 5x - 3$

SOLUTION:

The slope of the line with equation $y = 5x - 3$ is 5. The slope of the perpendicular line is the opposite reciprocal of 5, or $-\frac{1}{5}$.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 8 = -\frac{1}{5}(x - 3) \quad \text{Substitute.}$$

$$y - 8 = -\frac{1}{5}x + \frac{3}{5} \quad \text{Distributive Property}$$

$$y - 8 + 8 = -\frac{1}{5}x + \frac{3}{5} + 8 \quad \text{Add 8 to each side.}$$

$$y = -\frac{1}{5}x + 8\frac{3}{5} \quad \text{Simplify.}$$

4-4 Parallel and Perpendicular Lines

28. $(4, -2), y = 3x + 5$

SOLUTION:

The slope of the line with equation $y = 3x + 5$ is 3. The slope of the perpendicular line is the opposite reciprocal of 3, or $-\frac{1}{3}$.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - (-2) = -\frac{1}{3}(x - 4) \quad \text{Substitute.}$$

$$y - (-2) = -\frac{1}{3}x + 1\frac{1}{3} \quad \text{Distributive Property}$$

$$y + 2 = -\frac{1}{3}x + 1\frac{1}{3} \quad \text{Simplify.}$$

$$y + 2 - 2 = -\frac{1}{3}x + 1\frac{1}{3} - 2 \quad \text{Subtract.}$$

$$y = -\frac{1}{3}x - \frac{2}{3} \quad \text{Simplify.}$$

Write an equation in slope-intercept form for a line perpendicular to the graph of the equation that passes through the x -intercept of that line.

29. $y = -\frac{1}{2}x - 4$

SOLUTION:

The slope of the equation is $-\frac{1}{2}$, so the slope of the perpendicular line would be the opposite reciprocal, or 2. Find the x -intercept.

$$y = -\frac{1}{2}x - 4 \quad \text{Original equation}$$

$$0 = -\frac{1}{2}x - 4 \quad \text{Replace } y \text{ with } 0.$$

$$0 + 4 = -\frac{1}{2}x - 4 + 4 \quad \text{Add 4 to each side.}$$

$$4 = -\frac{1}{2}x \quad \text{Simplify.}$$

$$-2(4) = -2\left(-\frac{1}{2}x\right) \quad \text{Multiply each side by } -2.$$

$$-8 = x \quad \text{Simplify.}$$

Use the x -intercept $(-8, 0)$ and the slope, 2, to find the perpendicular line.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 0 = 2[x - (-8)] \quad \text{Substitute.}$$

$$y - 0 = 2[x + 8] \quad \text{Simplify.}$$

$$y = 2x + 16 \quad \text{Distributive Property}$$

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30. $y = \frac{2}{3}x - 6$

SOLUTION:

The slope of the equation is $\frac{2}{3}$, so the slope of the perpendicular line would be the opposite reciprocal, or $-\frac{3}{2}$. Find the x -intercept.

$$y = \frac{2}{3}x - 6 \quad \text{Original equation}$$

$$0 = \frac{2}{3}x - 6 \quad \text{Replace } y \text{ with } 0.$$

$$0 + 6 = \frac{2}{3}x - 6 + 6 \quad \text{Add } 6 \text{ to each side.}$$

$$6 = \frac{2}{3}x \quad \text{Simplify.}$$

$$\frac{3}{2}(6) = \frac{3}{2}\left(\frac{2}{3}x\right) \quad \text{Multiply each side by } \frac{3}{2}.$$

$$9 = x \quad \text{Simplify.}$$

Use the x -intercept $(9, 0)$ and the slope, $-\frac{3}{2}$, to find the perpendicular line.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 0 = -\frac{3}{2}(x - 9) \quad \text{Substitute.}$$

$$y = -\frac{3}{2}x + \frac{27}{2} \quad \text{Distributive Property}$$

4-4 Parallel and Perpendicular Lines

31. $y = 5x + 3$

SOLUTION:

The slope of the equation is 5, so the slope of the perpendicular line would be the opposite reciprocal, or $-\frac{1}{5}$. Find the x -intercept.

$$y = 5x + 3 \quad \text{Original equation}$$

$$0 = 5x + 3 \quad \text{Replace } y \text{ with } 0.$$

$$0 - 3 = 5x + 3 - 3 \quad \text{Subtract 3 from each side.}$$

$$-3 = 5x \quad \text{Simplify.}$$

$$\frac{-3}{5} = \frac{5x}{5} \quad \text{Divide each side by 5.}$$

$$-\frac{3}{5} = x \quad \text{Simplify.}$$

Use the x -intercept $\left(-\frac{3}{5}, 0\right)$ and the slope, $-\frac{1}{5}$, to find the perpendicular line.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 0 = -\frac{1}{5}\left[x - \left(-\frac{3}{5}\right)\right] \quad \text{Substitute.}$$

$$y - 0 = -\frac{1}{5}\left[x + \frac{3}{5}\right] \quad \text{Simplify.}$$

$$y = -\frac{1}{5}x - \frac{3}{25} \quad \text{Distributive Property}$$

4-4 Parallel and Perpendicular Lines

32. Write an equation in slope-intercept form for the line that is perpendicular to the graph of $3x + 2y = 8$ and passes through the y-intercept of that line.

SOLUTION:

Write the equation in slope-intercept form to find the slope.

$$3x + 2y = 8 \quad \text{Original equation}$$

$$3x - 3x + 2y = 8 - 3x \quad \text{Subtract } 3x \text{ from each side.}$$

$$2y = -3x + 8 \quad \text{Simplify.}$$

$$\frac{2y}{2} = \frac{-3x+8}{2} \quad \text{Divide each side by 2.}$$

$$y = -\frac{3}{2}x + 4 \quad \text{Simplify.}$$

The slope of the equation is $-\frac{3}{2}$, so the slope of the perpendicular line would be the opposite reciprocal, or $\frac{2}{3}$. Find the y-intercept.

$$y = -\frac{3}{2}x + 4 \quad \text{Original equation}$$

$$y = -\frac{3}{2}(0) + 4 \quad \text{Replace } x \text{ with 0.}$$

$$y = 4 \quad \text{Simplify.}$$

Use the y-intercept (0, 4) and the slope, $\frac{2}{3}$, to find the perpendicular line.

$$y - y_1 = m(x - x_1) \quad \text{Point-slope form}$$

$$y - 4 = \frac{2}{3}(x - 0) \quad \text{Substitute.}$$

$$y - 4 = \frac{2}{3}x - 0 \quad \text{Distributive Property}$$

$$y - 4 + 4 = \frac{2}{3}x - 0 + 4 \quad \text{Add 4 to each side.}$$

$$y = \frac{2}{3}x + 4 \quad \text{Simplify.}$$

4-4 Parallel and Perpendicular Lines

Determine whether the graphs of each pair of equations are *parallel*, *perpendicular*, or *neither*.

33. $y = 4x + 3$
 $4x + y = 3$

SOLUTION:

Write the second equation in slope-intercept form.

$$4x + y = 3 \quad \text{Original equation}$$

$$4x - 4x + y = 3 - 4x \quad \text{Subtract.}$$

$$y = -4x + 3 \quad \text{Simplify.}$$

The slope of $y = 4x + 3$ is 4 and the slope of $4x + y = 3$ is -4 . They are neither equal nor opposite reciprocals, so the graphs of the equations are neither parallel nor perpendicular.

34. $y = -2x$
 $2x + y = 3$

SOLUTION:

Write the second equation in slope-intercept form.

$$2x + y = 3 \quad \text{Original equation 2}$$

$$2x - 2x + y = 3 - 2x \quad \text{Subtract.}$$

$$y = -2x + 3 \quad \text{Simplify.}$$

The slope of the both equations is -2 so the graphs of the equations are parallel.

4-4 Parallel and Perpendicular Lines

35. $3x + 5y = 10$

$$5x - 3y = -6$$

SOLUTION:

Write the equations in slope-intercept form.

$$3x + 5y = 10 \quad \text{Original equation 1}$$

$$3x - 3x + 5y = 10 - 3x \quad \text{Subtract } 3x \text{ from each side.}$$

$$5y = -3x + 10 \quad \text{Simplify.}$$

$$\frac{5y}{5} = \frac{-3x+10}{5} \quad \text{Divide each side by 5.}$$

$$y = -\frac{3}{5}x + 2 \quad \text{Simplify.}$$

$$5x - 3y = -6 \quad \text{Original equation 2}$$

$$5x - 5x - 3y = -6 - 5x \quad \text{Subtract } 5x \text{ from each side.}$$

$$-3y = -5x - 6 \quad \text{Simplify.}$$

$$\frac{-3y}{-3} = \frac{-5x-6}{-3} \quad \text{Divide each side by } -3.$$

$$y = \frac{5}{3}x + 2 \quad \text{Simplify.}$$

The slope of the $3x + 5y = 10$ is $-\frac{3}{5}$ and the slope of $5x - 3y = -6$ is $\frac{5}{3}$. They are opposite reciprocals, so the graphs of the equations are perpendicular.

4-4 Parallel and Perpendicular Lines

$$\begin{aligned} 36. \quad & -3x + 4y = 8 \\ & -4x + 3y = -6 \end{aligned}$$

SOLUTION:

Write the equations in slope-intercept form.

$$-3x + 4y = 8 \quad \text{Original equation}$$

$$-3x + 3x + 4y = 8 + 3x \quad \text{Add } 3x \text{ to each side.}$$

$$4y = 3x + 8 \quad \text{Simplify.}$$

$$\frac{4y}{4} = \frac{3x+8}{4} \quad \text{Divide each side by 4.}$$

$$y = \frac{3}{4}x + 2 \quad \text{Simplify.}$$

$$-4x + 3y = -6 \quad \text{Original equation.}$$

$$-4x + 4x + 3y = -6 + 4x \quad \text{Add } 4x \text{ to each side.}$$

$$3y = 4x - 6 \quad \text{Simplify.}$$

$$\frac{3y}{3} = \frac{4x-6}{3} \quad \text{Divide each side by 3.}$$

$$y = \frac{4}{3}x - 2 \quad \text{Simplify.}$$

The slope of the first equation is $\frac{3}{4}$ and the slope of the second equation is $\frac{4}{3}$. They are neither equal nor opposite reciprocals, so the graphs of the equations are neither parallel nor perpendicular.

4-4 Parallel and Perpendicular Lines

37. $2x + 5y = 15$
 $3x + 5y = 15$

SOLUTION:

Write the equations in slope-intercept form.

$$2x + 5y = 15 \quad \text{Original equation 1}$$

$$2x - 2x + 5y = 15 - 2x \quad \text{Subtract } 2x \text{ from each side.}$$

$$5y = -2x + 15 \quad \text{Simplify.}$$

$$\frac{5y}{5} = \frac{-2x+15}{5} \quad \text{Divide each side by 5.}$$

$$y = -\frac{2}{5}x + 3 \quad \text{Simplify.}$$

$$3x + 5y = 15 \quad \text{Original equation 2}$$

$$3x - 3x + 5y = 15 - 3x \quad \text{Subtract } 3x \text{ from each side.}$$

$$5y = -3x + 15 \quad \text{Simplify.}$$

$$\frac{5y}{5} = \frac{-3x+15}{5} \quad \text{Divide each side by 5.}$$

$$y = -\frac{3}{5}x + 3 \quad \text{Simplify.}$$

The slope of the first equation is $-\frac{2}{5}$ and the slope of the second equation is $-\frac{3}{5}$. They are neither equal nor opposite reciprocals, so the graphs of the equations are neither parallel nor perpendicular.

4-4 Parallel and Perpendicular Lines

38. $2x + 7y = -35$
 $4x + 14y = -42$

SOLUTION:

Write the equations in slope-intercept form.

$$2x + 7y = -35 \quad \text{Original equation 1}$$

$$2x - 2x + 7y = -35 - 2x \quad \text{Subtract } 2x \text{ from each side.}$$

$$7y = -2x - 35 \quad \text{Simplify.}$$

$$\frac{7y}{7} = \frac{-2x-35}{7} \quad \text{Divide each side by 7.}$$

$$y = -\frac{2}{7}x - 5 \quad \text{Simplify.}$$

$$4x + 14y = -42 \quad \text{Original equation 2}$$

$$4x - 4x + 14y = -42 - 4x \quad \text{Subtract } 4x \text{ from each side.}$$

$$14y = -4x - 42 \quad \text{Simplify.}$$

$$\frac{14y}{14} = \frac{-4x-42}{14} \quad \text{Divide each side by 14.}$$

$$y = -\frac{2}{7}x - 3 \quad \text{Simplify.}$$

The slope of the both equations is $-\frac{2}{7}$ so the graphs of the equations are parallel.

39. Write an equation of the line that is parallel to the graph of $y = 7x - 3$ and passes through the origin.

SOLUTION:

The slope of the line with equation $y = 7x - 3$ is 7. The line parallel to $y = 7x - 3$ has the same slope, 7. The origin is the point (0, 0).

$$y - y_1 = m(x - x_1)$$

$$y - 0 = 7(x - 0)$$

$$y = 7x - 0$$

$$y = 7x$$

4-4 Parallel and Perpendicular Lines

40. **EXCAVATION** Scientists excavating a dinosaur mapped the site on a coordinate plane. If one bone lies from $(-5, 8)$ to $(10, -1)$ and a second bone lies from $(-10, -3)$ to $(-5, -6)$, are the bones parallel? Explain.

SOLUTION:

Find the slope of the first bone.

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-1 - 8}{10 - (-5)} \\ &= \frac{-9}{15} \\ &= -\frac{3}{5} \end{aligned}$$

Find the slope of the second bone.

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-6 - (-3)}{-5 - (-10)} \\ &= -\frac{3}{5} \end{aligned}$$

The two bones are parallel because their slopes are both $-\frac{3}{5}$.

4-4 Parallel and Perpendicular Lines

41. **ARCHAEOLOGY** In the ruins of an ancient civilization, an archaeologist found pottery at (2, 6) and hair accessories at (4, -1). A pole is found with one end at (7, 10) and the other end at (14, 12). Is the pole perpendicular to the line through the pottery and the hair accessories? Explain.

SOLUTION:

Find the slope of the line through the pottery and hair accessories.

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-1 - 6}{4 - 2} \\ &= -\frac{7}{2} \end{aligned}$$

Find the slope of the pole.

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{12 - 10}{14 - 7} \\ &= \frac{2}{7} \end{aligned}$$

The slope of the line through the pottery and hair accessories is $-\frac{7}{2}$ and the slope of the pole is $\frac{2}{7}$. They are opposite reciprocals, so they are perpendicular.

4-4 Parallel and Perpendicular Lines

42. **GRAPHICS** To create a design on a computer, Andeana must enter the coordinates for points on the design. One line segment she drew has endpoints of $(-2, 1)$ and $(4, 3)$. The other coordinates that Andeana entered are $(2, -7)$ and $(8, -3)$. Could these points be the vertices of a rectangle? Explain.

SOLUTION:

Find the slope of the first line segment she drew.

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{3 - 1}{4 - (-2)} \\ &= \frac{2}{6} \\ &= \frac{1}{3} \end{aligned}$$

Find the slope of the line segments that would be drawn between the other coordinates Andeana entered.

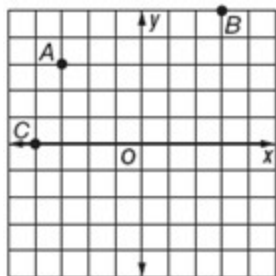
$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-3 - (-7)}{8 - 2} \\ &= \frac{4}{6} \\ &= \frac{2}{3} \end{aligned}$$

The slopes of these two line segments are not equal, so they are not parallel. Opposite sides of a rectangle must be parallel, so the points are not vertices of a rectangle.

43. **MULTIPLE REPRESENTATIONS** In this problem, you will explore parallel and perpendicular lines.
- GRAPHICAL** Graph the points $A(-3, 3)$, $B(3, 5)$, and $C(-4, 0)$ on a coordinate plane.
 - ANALYTICAL** Determine the coordinates of a fourth point D that would form a parallelogram. Explain your reasoning.
 - ANALYTICAL** What is the minimum number of points that could be moved to make the parallelogram a rectangle? Describe which points should be moved and explain why.

SOLUTION:

- a. To plot point A , start at the origin, go 3 units to the left and 3 units up. To plot point B , start at the origin, go 3 units to the right and 5 units up. To plot point C , start at the origin and go 4 units to the left.



4-4 Parallel and Perpendicular Lines

b. Looking at the graph, the slope of \overline{AB} is $\frac{1}{3}$ (up 1 unit, right 3 units). To form a parallelogram, \overline{CD} would have to have the same slope as \overline{AB} , $\frac{1}{3}$. So, using the same slope as \overline{AB} , find the y-intercept using the fact that \overline{CD} using the coordinate of C. Then write an equation for \overline{CD} .

$$y = \frac{1}{3}x + b \quad \text{Slope-intercept form of } \overline{CD}$$

$$0 = \frac{1}{3}(-4) + b \quad \text{Replace variable with } (-4, 0).$$

$$0 = -\frac{4}{3} + b \quad \text{Add } -\frac{4}{3} \text{ to each side.}$$

$$\frac{4}{3} = b \quad \text{Simplify.}$$

$$y = \frac{1}{3}x + \frac{4}{3} \quad \text{Add } \frac{4}{3} \text{ to each side.}$$

$$y = \frac{1}{3}x + \frac{4}{3} \quad \text{Simplify.}$$

Looking at the graph, the slope of \overline{AC} is 3 (up 3 units, right 1 unit). To form a parallelogram, \overline{BD} would have to have the same slope as \overline{AC} , 3. So, using the same slope as \overline{AC} , find the y-intercept and write an equation for \overline{BD} .

$$y = 3x + b \quad \text{Slope-intercept form of } \overline{BD}.$$

$$5 = 3(3) + b \quad \text{Replace } (x, y) \text{ with } (3, 5).$$

$$5 = 9 + b \quad \text{Add 9 to each side.}$$

$$5 - 9 = 9 - 9 + b \quad \text{Subtract 9 from each side.}$$

$$-4 = b \quad \text{Simplify.}$$

$$y = 3x - 4 \quad \overline{BD} \text{ in slope-intercept form.}$$

Find a point that is found on both equations. Set the equations equal to each other to find the x-coordinate. Then substitute that value into one of the equations to find the corresponding y-coordinate.

4-4 Parallel and Perpendicular Lines

$$\frac{1}{3}x + \frac{4}{3} = 3x - 4 \quad CD = BD$$

$$\frac{1}{3}x - \frac{1}{3}x + \frac{4}{3} = 3x - \frac{1}{3}x - 4 \quad \text{Subtract } \frac{1}{3}x \text{ from each side.}$$

$$1\frac{1}{3} = 2\frac{2}{3}x - 4 \quad \text{Simplify.}$$

$$1\frac{1}{3} + 4 = 2\frac{2}{3}x - 4 + 4 \quad \text{Add 4 from each side.}$$

$$5\frac{1}{3} = 2\frac{2}{3}x \quad \text{Simplify.}$$

$$\frac{16}{3} = \frac{8}{3}x \quad \text{Simplify.}$$

$$\frac{3}{8} \cdot \frac{16}{3} = \frac{3}{8} \cdot \frac{8}{3}x \quad \text{Multiply each side by } \frac{3}{8}.$$

$$2 = x \quad \text{Simplify.}$$

$$y = 3x - 4$$

$$y = 3(2) - 4$$

$$y = 6 - 4$$

$$y = 2$$

So to form a parallelogram, point D must be $(2, 2)$.

c. A minimum of 2 points must be moved to change a parallelogram into a rectangle. Either C and D should be moved or A and B should be moved to make \overline{AC} and \overline{BD} parallel.

44. **CHALLENGE** If the line through $(-2, 4)$ and $(5, d)$ is parallel to the graph of $y = 3x + 4$, what is the value of d ?

SOLUTION:

The slope of $y = 3x + 4$ is 3, so the slope of the line through the points must also be 3.

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

$$3 = \frac{d - 4}{5 - (-2)}$$

$$3 = \frac{d - 4}{7}$$

$$3 \cdot 7 = 7 \left(\frac{d - 4}{7} \right)$$

$$21 = d - 4$$

$$25 = d$$

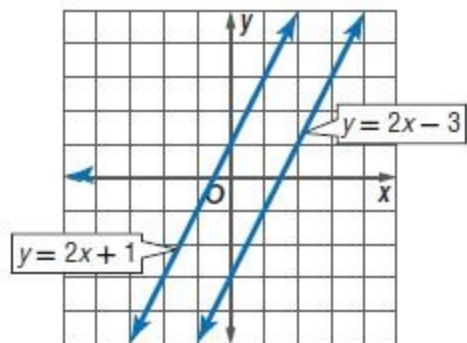
So, the value of d is 25.

4-4 Parallel and Perpendicular Lines

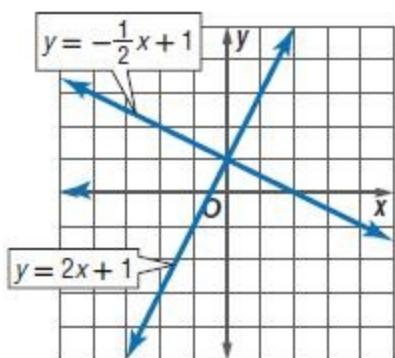
45. **REASONING** Which key features of the graphs of two parallel lines are the same, and which are different? Which key features of the graphs of two perpendicular lines are the same, and which are different?

SOLUTION:

Sample answer:



Parallel lines: similarities: The domain and range are all real numbers, the functions are both either increasing or decreasing on the entire domain, the end behavior is the same, and the lines will have the same slope; differences: x - and y -intercepts are different. Any point on one line will not be on the other.



Perpendicular lines: similarities: The domain and range are all real numbers, and the lines have one point in common; differences: One function is increasing and the other is decreasing on the entire domain, as x decreases, y increases for one function and decreases for the other and as x increases, y increases for one function and decreases for the other. The lines will have slopes that are opposite reciprocals.

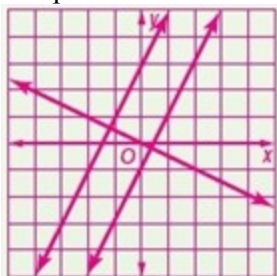
4-4 Parallel and Perpendicular Lines

46. **OPEN ENDED** Graph a line that is parallel and a line that is perpendicular to $y = 2x - 1$.

SOLUTION:

To graph a line that is parallel to $y = 2x - 1$, draw a line with the slope of 2 that has a y-intercept other than -1 . To graph a line that is perpendicular to $y = 2x - 1$, draw a line with the slope of $-\frac{1}{2}$.

Sample answer:



47. **CCSS CRITIQUE** Carmen and Chase are finding an equation of the line that is perpendicular to the graph of $y = \frac{1}{3}x + 2$ and passes through the point $(-3, 5)$. Is either of them correct? Explain your reasoning.

Carmen

$$\begin{aligned}y - 5 &= -3[x - (-3)] \\y - 5 &= -3(x + 3) \\y &= -3x - 9 + 5 \\y &= -3x - 4\end{aligned}$$

Chase

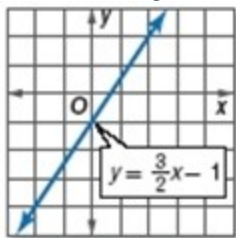
$$\begin{aligned}y - 5 &= 3[x - (-3)] \\y - 5 &= 3(x + 3) \\y &= 3x + 9 + 5 \\y &= 3x + 14\end{aligned}$$

SOLUTION:

Both students used the formula correctly and used the correct point, but only Carmen used the correct slope for a line that is perpendicular to $y = \frac{1}{3}x + 2$. The correct slope is -3 because it is the opposite reciprocal of the slope of the original line.

4-4 Parallel and Perpendicular Lines

48. **WRITING IN MATH** Illustrate how you can determine whether two lines are parallel or perpendicular. Write an equation for the graph that is parallel and an equation for the graph that is perpendicular to the line shown. Explain your reasoning



SOLUTION:

Sample answer: If two equations have the same slope, then the lines are parallel. If the product of their slopes equals -1 , then the lines are perpendicular. The graph of $y = \frac{3}{2}x$ is parallel to the graph of $y = \frac{3}{2}x + 1$ because they have the same slope, $\frac{3}{2}$. The graph of $y = -\frac{2}{3}x$ is perpendicular to the graph of $y = \frac{3}{2}x + 1$ because the product of their slopes is -1 .

49. Which of the following is an algebraic translation of the following phrase?
5 less than the quotient of a number and 8

- A $5 - \frac{n}{8}$
- B $\frac{n}{8} - 5$
- C $5 - \frac{8}{n}$
- D $\frac{8}{n} - 5$

SOLUTION:

Rewrite the phrase so it is easier to translate. *The quotient of a number and 8* means *a number divided by 8*. *5 less than* this means *5 is subtracted from this*.

<i>a number divided by eight</i>	<i>minus</i>	<i>five</i>
$n \div 8$	—	5
$\frac{n}{8}$	—	5

So, the correct choice is B.

4-4 Parallel and Perpendicular Lines

50. A line through which two points would be parallel to a line with a slope of $\frac{3}{4}$?

F (0, 5) and (-4, 2)

G (0, 2) and (-4, 1)

H (0, 0) and (0, -2)

J (0, -2) and (-4, -2)

SOLUTION:

Find the slope of the points for choice F.

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

$$m = \frac{2 - 5}{-4 - 0}$$

$$m = \frac{-3}{-4}$$

$$m = \frac{3}{4}$$

This is the same slope as that of the given line, so the correct choice is F.

4-4 Parallel and Perpendicular Lines

51. Which equation best fits the data in the table?

x	y
1	5
2	7
3	9
4	11

A $y = x + 4$

B $y = 2x + 3$

C $y = 7$

D $y = 4x - 5$

SOLUTION:

Substitute the x -values from the table into each equation to determine if y -value is the same.

Choice A:

x	$y = x + 4$	y
1	$y = (1) + 4$	5
2	$y = (2) + 4$	6
3	$y = (3) + 4$	5
4	$y = (4) + 4$	8

Choice B:

x	$y = 2x + 3$	y
1	$y = 2(1) + 3$	5
2	$y = 2(2) + 3$	7
3	$y = 2(3) + 3$	9
4	$y = 2(4) + 3$	11

Choice C:

x	$y = 7$	y
1	$y = 7$	7
2	$y = 7$	7
3	$y = 7$	7
4	$y = 7$	7

Choice D:

x	$y = 4x - 5$	y
1	$y = 4(1) - 5$	-1
2	$y = 4(2) - 5$	3
3	$y = 4(3) - 5$	7
4	$y = 4(4) - 5$	11

Equation B is true for all values in the table. So, the correct choice is B.

4-4 Parallel and Perpendicular Lines

52. **SHORT RESPONSE** Tyler is filling his 6000-gallon pool at a constant rate. After 4 hours, the pool contained 800 gallons. How many total hours will it take to completely fill the pool?

SOLUTION:

Use proportion to find the number of hours to fill a 6000-gallon pool.

$$\frac{4}{800} = \frac{x}{6000} \quad \text{Proportion}$$

$$4(6000) = 800x \quad \text{Find the cross products.}$$

$$24,000 = 800x \quad \text{Simplify.}$$

$$\frac{24,000}{800} = \frac{800x}{800} \quad \text{Divide each side by 800.}$$

$$30 = x \quad \text{Simplify.}$$

So, it will take 30 hours to completely fill the pool.

Write each equation in standard form.

53. $y - 13 = 4(x - 2)$

SOLUTION:

$$y - 13 = 4(x - 2)$$

$$y - 13 = 4x - 8$$

$$y = 4x + 5$$

$$-4x + y = 5$$

$$4x - y = -5$$

54. $y - 5 = -2(x + 2)$

SOLUTION:

$$y - 5 = -2(x + 2)$$

$$y - 5 = -2x - 4$$

$$y = -2x + 1$$

$$2x + y = 1$$

55. $y + 3 = -5(x + 1)$

SOLUTION:

$$y + 3 = -5(x + 1)$$

$$y + 3 = -5x - 5$$

$$y = -5x - 8$$

$$5x + y = -8$$

4-4 Parallel and Perpendicular Lines

$$56. y + 7 = \frac{1}{2}(x + 2)$$

SOLUTION:

$$y + 7 = \frac{1}{2}(x + 2)$$

$$y + 7 = \frac{1}{2}x + 1$$

$$y = \frac{1}{2}x - 6$$

$$2 \cdot y = 2\left(\frac{1}{2}x - 6\right)$$

$$2y = x - 12$$

$$-x + 2y = -12$$

$$x - 2y = 12$$

$$57. y - 1 = \frac{5}{6}(x - 4)$$

SOLUTION:

$$y - 1 = \frac{5}{6}(x - 4) \quad \text{Original equation}$$

$$y - 1 = \frac{5}{6}x - \frac{10}{3} \quad \text{Distributive Property}$$

$$6(y - 1) = 6\left(\frac{5}{6}x - \frac{10}{3}\right) \quad \text{Multiply each side by 6.}$$

$$6y - 6 = 5x - 20 \quad \text{Distributive Property}$$

$$6y - 6 + 6 = 5x - 20 + 6 \quad \text{Add 6 to each side.}$$

$$6y = 5x - 14 \quad \text{Simplify.}$$

$$-5x + 6y = 5x - 5x - 14 \quad \text{Subtract } 5x \text{ from each side.}$$

$$-5x + 6y = -14 \quad \text{Simplify.}$$

$$-1(-5x + 6y) = -1(-14) \quad \text{Multiply each side by } -1.$$

$$5x - 6y = 14 \quad \text{Simplify.}$$

4-4 Parallel and Perpendicular Lines

$$58. y - 2 = -\frac{2}{5}(x - 8)$$

SOLUTION:

$$y - 2 = -\frac{2}{5}(x - 8)$$

$$y - 2 = -\frac{2}{5}x + \frac{16}{5}$$

$$5(y - 2) = 5\left(-\frac{2}{5}x + \frac{16}{5}\right)$$

$$5y - 10 = -2x + 16$$

$$5y = -2x + 26$$

$$2x + 5y = 26$$

59. **CANOE RENTAL** Latanya and her friends rented a canoe for 3 hours and paid a total of \$45.



- Write a linear equation to find the total cost C of renting the canoe for h hours.
- How much would it cost to rent the canoe for 8 hours?

SOLUTION:

- Find the constant daily rate.

$$y = mx + b$$

$$45 = 10(3) + b$$

$$45 = 30 + b$$

$$15 = b$$

Write the equation.

$$C = 10h + 15$$

- $C = 10(8) + 15$

$$C = 80 + 15$$

$$C = 95$$

So, the cost to rent a canoe for 8 hours is \$95.

4-4 Parallel and Perpendicular Lines

Write an equation of the line that passes through each point with the given slope.

60. $(5, -2), m = 3$

SOLUTION:

Find the y-intercept.

$$y = mx + b$$

$$-2 = 3(5) + b$$

$$-2 = 15 + b$$

$$-17 = b$$

Write the equation in slope-intercept form.

$$y = mx + b$$

$$y = 3x - 17$$

61. $(-5, 4), m = -5$

SOLUTION:

Find the y-intercept.

$$y = mx + b$$

$$4 = -5(-5) + b$$

$$4 = 25 + b$$

$$-21 = b$$

Write the equation in slope-intercept form.

$$y = mx + b$$

$$y = -5x - 21$$

62. $(3, 0), m = -2$

SOLUTION:

Find the y-intercept.

$$y = mx + b$$

$$0 = -2(3) + b$$

$$0 = -6 + b$$

$$6 = b$$

Write the equation in slope-intercept form.

$$y = mx + b$$

$$y = -2x + 6$$

4-4 Parallel and Perpendicular Lines

63. $(3, 5), m = 2$

SOLUTION:

Find the y-intercept.

$$y = mx + b$$

$$5 = 2(3) + b$$

$$5 = 6 + b$$

$$-1 = b$$

Write the equation in slope-intercept form.

$$y = mx + b$$

$$y = 2x - 1$$

64. $(-3, -1), m = -3$

SOLUTION:

Find the y-intercept.

$$y = mx + b$$

$$-1 = -3(-3) + b$$

$$-1 = 9 + b$$

$$-10 = b$$

Write the equation in slope-intercept form.

$$y = mx + b$$

$$y = -3x - 10$$

65. $(-2, 4), m = -5$

SOLUTION:

Find the y-intercept.

$$y = mx + b$$

$$4 = -5(-2) + b$$

$$4 = 10 + b$$

$$-6 = b$$

Write the equation in slope-intercept form.

$$y = mx + b$$

$$y = -5x - 6$$

Simplify each expression. If not possible, write *simplified*.

66. $13m + m$

SOLUTION:

$$13m + m = 14m$$

67. $14a^2 + 13b^2 + 27$

SOLUTION:

There are no like terms to be combined. The expression is already simplified.

4-4 Parallel and Perpendicular Lines

68. $3(x + 2x)$

SOLUTION:

$$\begin{aligned} 3(x + 2x) &= 3x + 6x \\ &= 9x \end{aligned}$$

69. **FINANCIAL LITERACY** At a Farmers' Market, merchants can rent a small table for \$5.00 and a large table for \$8.50. One time, 25 small and 10 large tables were rented. Another time, 35 small and 12 large were rented.

- Write an algebraic expression to show the total amount of money collected.
- Evaluate the expression.

SOLUTION:

a. $25(5) + 10(8.5) + 35(5) + 12(8.5)$

b. $25(5) + 10(8.5) + 35(5) + 12(8.5) = 125 + 85 + 175 + 102$
 $= 487$

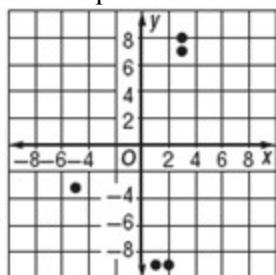
So the total amount of money collected is \$487.

Express each relation as a graph. Then determine the domain and range.

70. $\{(3, 8), (3, 7), (2, -9), (1, -9), (-5, -3)\}$

SOLUTION:

Plot the points.

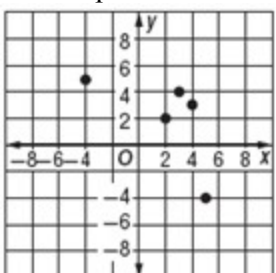


The domain is all x values of the relation, and the range is all y values of the relation. So, the domain is $\{-5, 1, 2, 3\}$ and the range is $\{-9, -3, 7, 8\}$.

71. $\{(3, 4), (4, 3), (2, 2), (5, -4), (-4, 5)\}$

SOLUTION:

Plot the points.



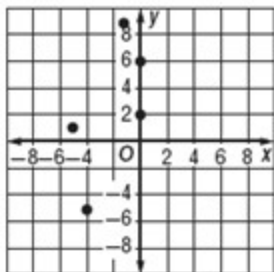
The domain is all x values of the relation, and the range is all y values of the relation. So, the domain is $\{-4, 2, 3, 4, 5\}$ and the range is $\{-4, 2, 3, 4, 5\}$.

4-4 Parallel and Perpendicular Lines

72. $\{(0, 2), (-5, 1), (0, 6), (-1, 9), (-4, -5)\}$

SOLUTION:

Plot the points.

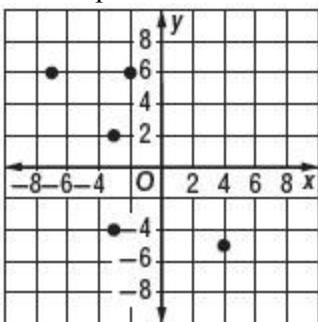


The domain is all x values of the relation, and the range is all y values of the relation. So, the domain is $\{-5, -4, -1, 0\}$ and the range is $\{-5, 1, 2, 6, 9\}$.

73. $\{(-7, 6), (-3, -4), (4, -5), (-2, 6), (-3, 2)\}$

SOLUTION:

Plot the points.



The domain is all x values of the relation, and the range is all y values of the relation. So, the domain is $\{-7, -3, 4, -2\}$ and the range is $\{6, -4, -5, 2\}$.