6

A ball falls from a platform that is 150 feet above the ground. The function $h(t) = 150 - 16t^2$ gives the ball's height, in feet, above the ground t seconds after it falls. Which of the following is the best interpretation of $h(3) = 6$ in this context?

A) The ball is 3 feet above the ground 6 seconds after it falls.
B) The ball is 3 feet below the platform 6 seconds after it falls.
C) The ball is 6 feet above the ground 3 seconds after it falls.
D) The ball is 6 feet below the platform 3 seconds after it falls.

7

If $f(x) = x^2$, for which of the following values of c is $f(c) < c$?

A) $\frac{1}{2}$
B) 1
C) $\frac{3}{2}$
D) 2

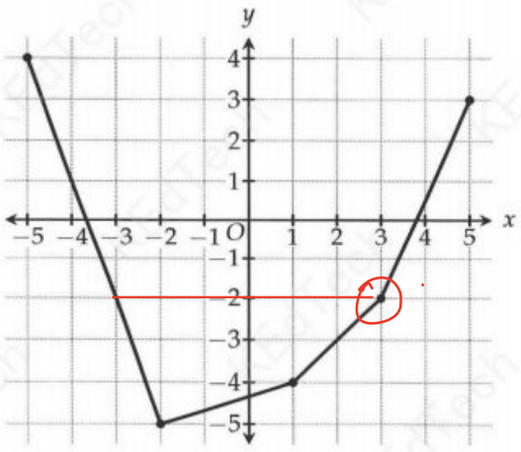
8

$$f(x) = 4x - 3$$
$$g(x) = 3x + 5$$

The functions f and g are defined by the given equations. Which of the following is equal to $f(8)$?

A) $g(1)$
B) $g(3)$
C) $g(5)$
D) $g(8)$

9



The graph of $y = f(x)$ is shown in the xy-plane. If $f(a) = f(3)$, which of the following could be the value of a ?

A) -4
B) -3
C) -2
D) 1

10

$$f(x) = x^2 + 1$$
$$g(x) = x^2 - 1$$

The functions f and g are defined by the given equations. What is the value of $f(g(2))$?

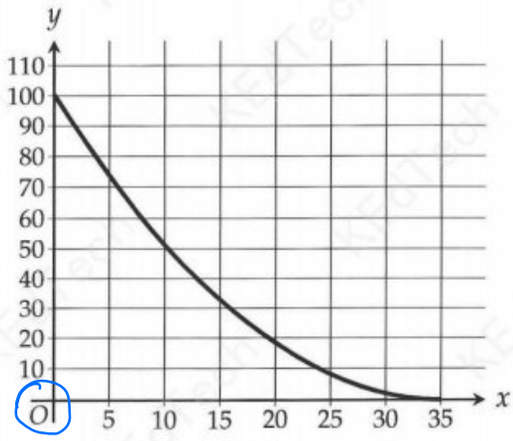
A) 3
B) 5
C) 10
D) 17

11

The function f is defined by $f(x) = 3x + 2$ and the function g is defined by $g(x) = f(2x) - 1$. What is the value of $g(10)$?

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12



The graph gives the atmospheric pressure y, in kilopascals, that corresponds to an elevation of x kilometers above sea level. Which statement is the best interpretation of the y-intercept in this context?

A) The atmospheric pressure at sea level is about 35 kilopascals.

B) The atmospheric pressure at sea level is about 100 kilopascals.

C) The atmospheric pressure at 35 kilometers above sea level is about 0 kilopascals.

D) The atmospheric pressure at 100 kilometers above sea level is about 0 kilopascals.

13

The function f is defined by $f(x) = -3x + 5$, and $\frac{1}{2}f(a) = 10$, where a is a constant. What is the value of a ?

A) -8

B) -5

C) 5

D) 8

14

The graph of $y = f(x)$ in the xy-plane has exactly two x-intercepts at $(r, 0)$ and $(s, 0)$, where r and s are positive constants. Which of the following equations could define f ?

A) $f(x) = (x + r)(x + s)$

B) $f(x) = x(x + r)(x + s)$

C) $f(x) = (x - r)(x - s)$

D) $f(x) = x(x - r)(x - s)$

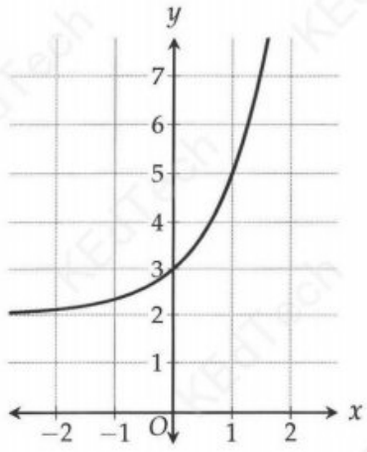
$x = r, s$

$(x - r) = 0$

$(x - s) = 0$

$x = r \quad x = s$

15



The graph of $y = 3^x + b$ is shown, where b is a constant. What is the value of b ?

A) 1

B) 2

C) 3

D) 4

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16

Function f is defined by $f(x) = x(x+2)(x+6)$. Which table of values represents $y = f(x-2)$?

A)

x	y
-8	0
-4	0
-2	0

B)

x	y
-4	0
0	0
2	0

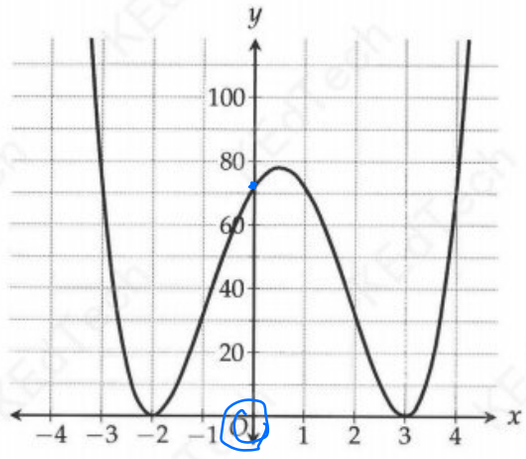
C)

x	y
-2	0
0	0
4	0

D)

x	y
2	0
4	0
8	0

17



Which of the following could be the equation of the graph shown?

A) $y = (x+2)^2(x-3)^2$

B) $y = (x-2)^2(x+3)^2$

C) $y = 2(x+2)^2(x-3)^2$

D) $y = 2(x-2)^2(x+3)^2$

18

Function f is defined by $f(x) = (x+2)(x-2)^2$. The graph of $y = f(x)$ in the xy-plane passes through the point (p, q), where $-2 \le p \le 2$. Which of the following is NOT a possible value of q?

A) 12

B) 8

C) 4

D) 0

19

If $f(x+1) = \frac{1}{4}f(x)$, which of the following equations could define the function f?

A) $f(x) = \frac{1}{4}\left(\frac{1}{8}\right)^x$

B) $f(x) = 8\left(\frac{1}{4}\right)^x$

C) $f(x) = 8(4)^x$

D) $f(x) = \frac{1}{4}(8)^x$

20

x	0	1	2
$f(x)$	-2	3	18

Function f is defined by $f(x) = ax^2 + b$, where a and b are constants. The table gives three values of x and their corresponding values of $f(x)$. What is the value of $f(3)$?

A) 23

B) 39

C) 43

D) 56

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6

Lines & Linear Relationships

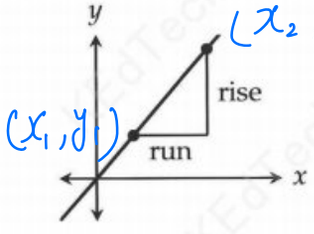
Lines in the xy-plane represent functions of the form $f(x) = mx + b$, which are often referred to as linear functions. Let's dive into some properties you'll need to know.

Given any two points (x_1, y_1) and (x_2, y_2) on a line, the

$$\text{slope of the line} = \frac{\text{rise}}{\text{run}} = \frac{y_2 - y_1}{x_2 - x_1}$$

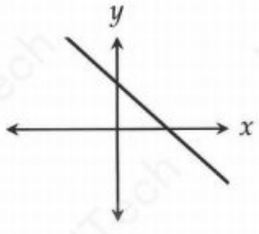
The slope is a measure of the steepness of a line—the larger the slope, the more steep the line is. The rise is the distance between the y coordinates and the run is the distance between the x coordinates. A slope of 2 means that the line goes 2 units up for every 1 unit to the right, or 2 units down for every 1 unit to the left. A slope of $-\frac{2}{3}$ means that the line goes 2 units down for every 3 units to the right, or 2 units up for every 3 units to the left.

Lines with positive slope always go up and to the right as shown below.



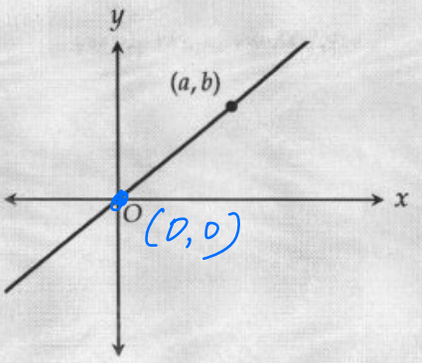
$$\text{slope} = \frac{y_2 - y_1}{x_2 - x_1}$$

Lines with negative slope go down and to the right:



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EXAMPLE 1:



$$\text{slop} = \frac{y_2 - y_1}{x_2 - x_1}$$

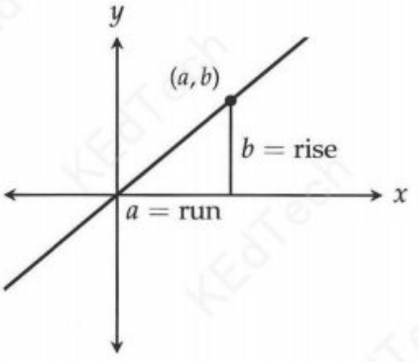
$$= \frac{b-0}{a-0} = \frac{b}{a}$$

The line shown in the xy-plane passes through the point $(0,0)$ and the point (a,b), where $a > b$. Which of the following could be the slope of this line?

$$0 < \frac{b}{a} < 1$$

A) $-\frac{1}{2}$ B) $\frac{3}{4}$ C) 1 D) $\frac{3}{2}$

First, notice that the slope is positive. The slope, $\frac{\text{rise}}{\text{run}}$, is also equal to $\frac{b}{a}$.



Since $a > b$, $\frac{b}{a}$ is always less than 1. For example, if $a = 5$ and $b = 3$, the slope would be $\frac{3}{5}$. The only choice that's both positive and less than 1 is answer $\boxed{(B)}$.

EXAMPLE 2: Line m passes through the points $(k,7)$ and $(3,k-4)$ in the xy-plane. If the slope of line m is 3, what is the value of k?

$$\text{Slope} = \frac{(k-4)-7}{3-k} = 3$$

$$k - 11 = 3(3-k)$$

$$k - 11 = 9 - 3k$$

$$4k = 20$$

$$k = \boxed{5}$$

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In addition to slope, you also need to know what x and y intercepts are. The x-intercept is where the graph crosses the x-axis. Likewise, the y-intercept is where the graph crosses the y-axis.

Let's say we have the line defined by

$$2x + 3y = 12$$

- To find the x-intercept, set y equal to 0. $(a, 0)$

$$\begin{aligned} 2x + 3(0) &= 12 \\ 2x &= 12 \\ x &= 6 \end{aligned}$$

The x-intercept is $(6, 0)$.

To find the y-intercept, set x equal to 0. $(0, b)$

$$\begin{aligned} 2(0) + 3y &= 12 \\ 3y &= 12 \\ y &= 4 \end{aligned}$$

The y-intercept is $(0, 4)$.

EXAMPLE 3: The function f is defined by $f(x) = 3x + 12$. What is the x-intercept of the graph of $y = f(x)$ in the xy-plane?

A) $(12, 0)$ B) $(4, 0)$ C) $(-4, 0)$ D) $(-12, 0)$

The graph of the function in the xy-plane is defined by the equation $y = 3x + 12$. To find the x-intercept, set y equal to 0:

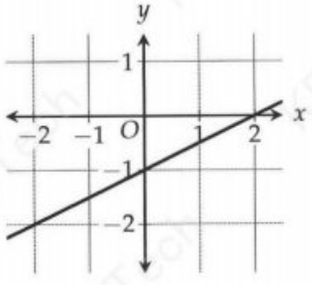
$$\begin{aligned} 0 &= 3x + 12 \\ -12 &= 3x \\ -4 &= x \end{aligned}$$

Therefore, the x-intercept of the graph is $(-4, 0)$, answer $\boxed{(C)}$.

All lines can be expressed in **slope-intercept form**:

$$y = mx + b$$

where m is the slope and b is the y-intercept. So for the line $y = \frac{1}{2}x - 1$, the slope is $\frac{1}{2}$ and the y-intercept is -1:



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While all lines can be expressed in slope-intercept form, sometimes it'll take some work to get there. If you're given a slope and a y-intercept, then of course it's most convenient to express the line in slope-intercept form. But what if we're handed a slope and a point instead of a slope and a y-intercept? Then it'll be more convenient to use **point-slope form**:

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

where (x_1, y_1) is the given point.

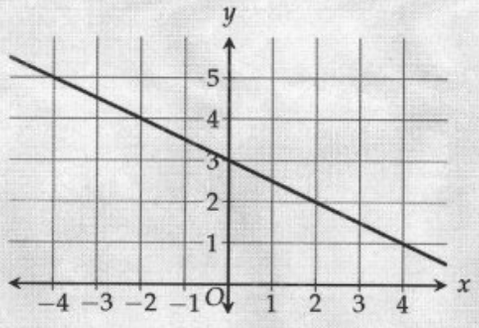
Let's say we want to find the equation of a line that has a slope of 3 and passes through the point $(1, -2)$. The equation of the line in point-slope form is then

$$y - (-2) = 3(x - 1)$$

Once it's in this form, we can manipulate the equation to get the slope-intercept form of the line if needed:

$$\begin{aligned} y - (-2) &= 3(x - 1) \\ y + 2 &= 3x - 3 \\ y &= 3x - 5 \end{aligned}$$

EXAMPLE 4:



What is an equation of the graph shown?

A) $y = -2x + 3$ B) $y = \frac{1}{2}x + 3$ C) $y = -\frac{1}{2}x + 3$ D) $y = 2x - 3$

All the answer choices are in slope-intercept form. To get the equation of the line in slope-intercept form, $y = mx + b$, we need to find the slope m and the y-intercept b. The line crosses the y-axis at 3, so $b = 3$. The line goes down 1 unit for every 2 units to the right, so the slope m is $-\frac{1}{2}$. Therefore, the equation of the line is $y = -\frac{1}{2}x + 3$. Answer $\boxed{(C)}$.

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EXAMPLE 5: Line l passes through the points $(-2,3)$ and $(3,13)$ in the xy-plane. What is the y-coordinate of the y-intercept of line l ?

The slope of line l is $\frac{y_2-y_1}{x_2-x_1}=\frac{13-3}{3-(-2)}=2$. With the given point $(3,13)$, we can use point-slope form to find the equation of the line:

$$y-13=2(x-3)$$

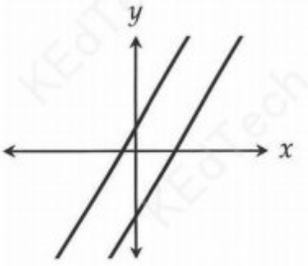
Note that we could've used the other point $(-2,3)$; the result will be the same. The next step is to simplify this equation to get the slope-intercept form of the line:

$$\begin{aligned} y-13&=2(x-3)\\ y&=2x-6+13\\ y&=2x+7 \end{aligned}$$

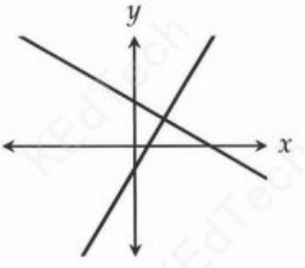
Now we can easily see that the y-coordinate of the y-intercept is $\boxed{7}$.

There are a few more things you need to know about lines.

Two lines are parallel if they have the same slope.



Two lines are perpendicular if the product of their slopes is -1. In other words, if one slope is the negative reciprocal of the other (e.g. 2 and $-\frac{1}{2}$).



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EXAMPLE 6: Line m has a slope of $\frac{2}{3}$ and passes through the point $(4,3)$ in the xy-plane. Line n is perpendicular to line m and passes through the same point $(4,3)$. Which equation defines line n ?

A) $y=-\frac{2}{3}x+9$ B) $y=-\frac{3}{2}x-3$ C) $y=-\frac{3}{2}x+6$ D) $y=-\frac{3}{2}x+9$

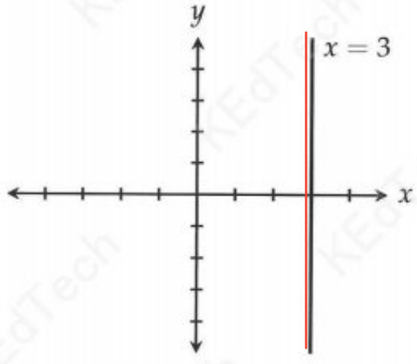
Because it's perpendicular to line m, line n must have a slope of $-\frac{3}{2}$ (the negative reciprocal). Now we can use point-slope form and simplify:

$$y-3=-\frac{3}{2}(x-4)$$
$$y=-\frac{3}{2}x+6+3$$
$$y=-\frac{3}{2}x+9$$

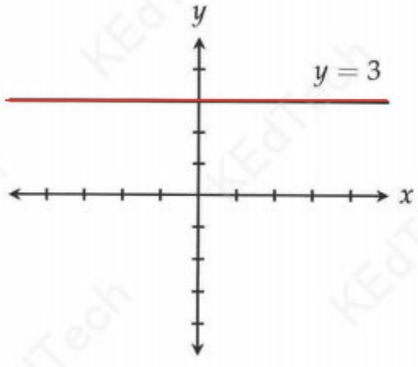
Answer $\boxed{(D)}$.

Finally, let's take a look at the equations of horizontal and vertical lines.

The equation of the vertical line that passes through $(3,0)$ is $x=3$. Every point on the line has an x-coordinate of 3.



The equation of the horizontal line that passes through $(0,3)$ is $y=3$.



Every point on the line has a y-coordinate of 3.

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EXERCISE 1: Answers for this exercise start on page 333.

1

What is the slope of a line that is perpendicular to the graph of $y = -\frac{1}{4}x + 5$ in the xy-plane?

4

2

What is the x-intercept of the graph of $8x + 12y = 48$ in the xy-plane?

A) $(4, 0)$
B) $(6, 0)$
C) $(8, 0)$
D) $(12, 0)$

3

In the xy-plane, the y-intercept of the graph of $5x - 8y = 40$ is $(0, c)$. What is the value of c ?

-5

4

In the xy-plane, line w has a slope of -8 and passes through the point $\left(\frac{1}{2}, -1\right)$. Which equation defines line w ?

A) $y = \frac{1}{2}x - 1$
B) $y = -8x - 5$
C) $y = -8x + 3$
D) $y = 8x - 5$

5

What is the slope of the graph of $y = -11x - \frac{2}{5}(18 - 6x)$ in the xy-plane?

$= -11x - \frac{36}{5} + \frac{12x}{5}$ -8.6

$=$

6

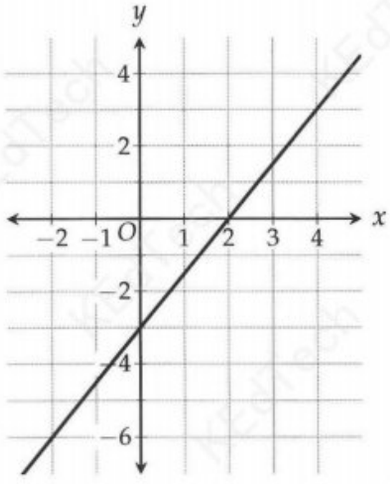
In the xy-plane, a line has an x-intercept at $(-2, 0)$ and a y-intercept at $(0, -4)$. What is the slope of the line?

A) -2
B) $-\frac{1}{2}$
C) $\frac{1}{2}$
D) 2

$\frac{-4-0}{0-(-2)} = \frac{-4}{2}$

$= -2$

7



The graph of line l is shown in the xy-plane. Which of the following is an equation of a line that is parallel to line l ?

A) $y = -\frac{2}{3}x + 2$
B) $y = \frac{2}{3}x + 10$
C) $y = \frac{3}{2}x - 4$
D) $y = 3x - 1$

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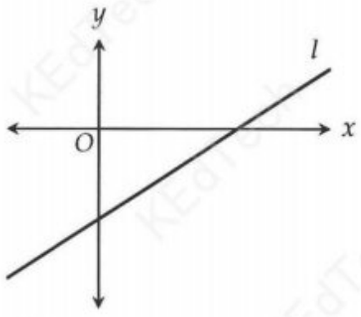
8

Day	Average speed, s (miles per hour)	Number of calories burned, c
Monday	7.2	616
Thursday	6.8	584
Friday	7.9	672
Saturday	8.5	720

On certain days of the week, Elaine runs for an hour on a treadmill. For each day that she ran on the treadmill last week, the table shows the average speed s at which she ran, in miles per hour, and the number of calories c she burned during the run. If the relationship between c and s can be modeled by a linear function, which of the following functions models this relationship?

A) $c(s) = 30s + 400$
B) $c(s) = 60s + 210$
C) $c(s) = 80s + 40$
D) $c(s) = 90s - 30$

9



The graph of line l is shown in the xy-plane. If line l can be represented by the equation $y = mx + b$, where m and b are constants, which of the following must be true?

A) $mb > 0$
B) $mb < 0$
C) $mb = 0$
D) $mb = 1$

10

Line k passes through the point $(1, 5)$ in the xy-plane. If line k is perpendicular to the line with equation $y = \frac{1}{2}x + 3$, which equation defines line k?

A) $y = -2x + 3$
B) $y = -2x + 7$
C) $y = -\frac{1}{2}x + \frac{11}{2}$
D) $y = \frac{1}{2}x + \frac{9}{2}$

11

In the xy-plane, a line with a slope of $\frac{1}{3}$ passes through the points $(-1, 1)$ and $(5, n)$. What is the value of n?

A) 9
B) 4
C) 3
D) $\frac{7}{3}$

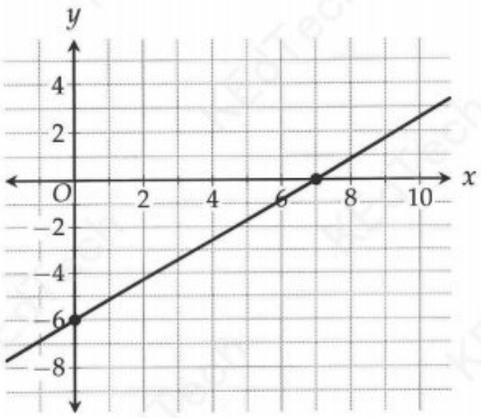
12

x	$f(x)$
-3	10
3	14
9	18

The table shows several values of x and their corresponding values of $f(x)$. There is a linear relationship between x and $f(x)$ that is defined by the equation $f(x) = ax + b$, where a and b are constants. What is the value of ab?

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13



Line p is shown in the xy-plane, and the point with coordinates $(5, r)$ lies on line p. What is the value of r ?

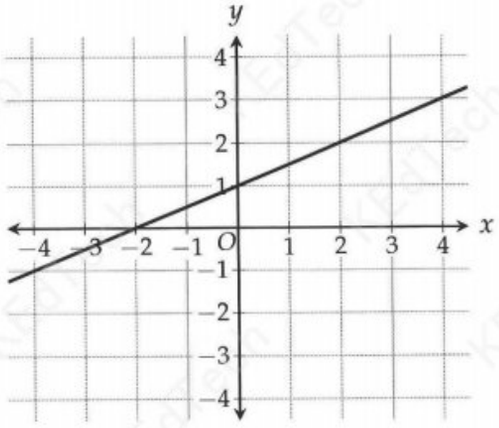
A) $-\frac{5}{3}$

B) $-\frac{11}{6}$

C) $-\frac{11}{7}$

D) $-\frac{12}{7}$

14



Line r is shown in the xy-plane. Line s (not shown) is parallel to line r and passes through the point $(1, -1)$. Which of the following points lies on line s ?

A) $(-3, -3)$

B) $(-2, -2)$

C) $(0, -2)$

D) $(4, 0)$

15

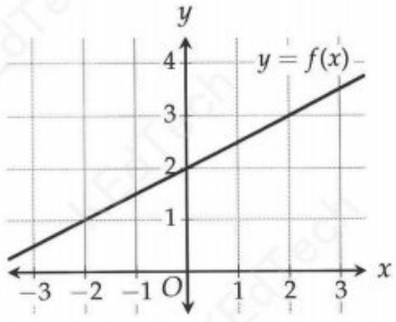
$$6x + y = 17$$
$$hx - 9y = -8$$

In the given pair of equations, h is a constant. The graphs of the equations in the xy-plane are perpendicular lines. What is the value of h ?

16

A line in the xy-plane passes through the point $(6, -3)$ and crosses the x-axis at the point $(15, 0)$. If the line also passes through the point $(-9, t)$, what is the value of t ?

17



In the xy-plane, the graph of the linear function f is perpendicular to the graph of the linear function g (not shown). If the graphs of f and g intersect at the point $\left(1, \frac{5}{2}\right)$, what is the value of $g(-1)$?

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