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18 Linear Functions



Introduction

A **linear function** is any function with a graph that is a straight line. The equation for a linear function can be written in slope-intercept form, $y = mx + b$, where m is the **slope** and b is the **y-intercept**. The slope is the rate of change or how steep the line is. Slope is shown as the ratio of the change in y to the change in x . The y -intercept is where the graph crosses the y -axis at the point $(0, b)$.

Which of these equations is a linear function?

Equation 1: $y = 2x^2 + 3$

Equation 3: $y = x^3$

Equation 2: $-5x + y = 1$

Equation 4: $y = \frac{3}{x-1}$

In equations 1 and 3, x is raised to a power, so these equations are not linear. In equation 4, x appears in the denominator, so it is not linear. Equation 2 can be written in slope-intercept form by adding $5x$ to both sides.

$$\begin{aligned} -5x + y &= 1 \\ -5x + 5x + y &= 5x + 1 \\ y &= 5x + 1 \end{aligned}$$

Equation 2 is a linear equation.

You can use an input-output table, a graph, or two points on a line to write a linear equation.

Write a linear equation from the values in the table.

x	-3	0	3	6	9
y	-1	5	11	17	23

To determine the slope, pick any two points and use the slope formula. Use $(0, 5)$ and $(-3, -1)$.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{5 - (-1)}{0 - (-3)} = \frac{5 + 1}{0 + 3} = \frac{6}{3} = 2$$

To determine the y -intercept, find the value of y when x is 0. In the table, the value of y is 5 when x is 0. The slope is 2 and the y -intercept is 5. So, $m = 2$ and $b = 5$.

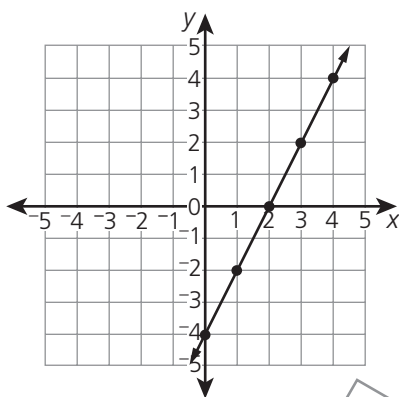
The equation is $y = 2x + 5$.

You can write any linear equation in slope-intercept form by isolating y using inverse operations.

A function is nonlinear if one of the variables is raised to a power, inside absolute value symbols, or in the denominator of a fraction when solved for one of the variables.

When using the slope formula $m = \frac{y_2 - y_1}{x_2 - x_1}$, make sure to pick points that are ordered pairs.

Write a linear equation from the graph.



The graph crosses the y -axis at -4 , so the y -intercept is -4 .

To find the rate of change, pick any two points and use the slope formula:

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{4 - 2}{4 - 3} = \frac{2}{1} = 2$$

So, the equation is $y = 2x - 4$.

Think About It



What is an example of a linear relationship in your daily life?



Focused Instruction

Many real-life situations can be modeled with a linear function. Think about the relationship between the variables and the constants in the situation.

- ▶ The Parker family went camping. The campground charged an entrance fee of \$20 and \$10 per night. Write a function to determine the total cost, y , for a camping trip for x nights.

How much does the campground charge per night? _____

How much does the campground charge for entrance? _____

What does x represent in this problem? _____

Write an expression to represent the cost for x nights of camping only.

Is the entrance fee a constant or does it change?

Is the entrance fee added to or subtracted from the cost per night to camp? _____

What does y represent in this problem? _____

Think about the slope-intercept form of an equation. Which value represents m in this problem? _____ Which value represents b ? _____

Write an equation in slope-intercept form representing the total cost for x nights of camping. _____

A constant is a value that does not change.

The slope-intercept form for a linear equation is $y = mx + b$.

Use information in a situation to find the slope and write an equation for a linear function.

- ▶ A candle is 12 inches tall. After it burns for 4 hours, it is 9 inches tall. Cam graphs the relationship between the height of the candle, y , and the amount of time it burns, x .

What is the initial height of the candle? _____

What is the value of y when x is 0? _____ Write this as an ordered pair. _____

What is the value of y when x is 4? _____ Write this as an ordered pair. _____

Use the two points you found above to find the slope of this linear function. _____

Use the slope and the y -intercept to write the equation describing this linear function. _____

Sometimes you must find ordered pairs for points in the information in a problem.

Slope formula:

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

Use information in a table to determine if a function is linear.

- Zachary completed a science project to determine the height (h) of a helium balloon over time (t). The results of the experiment are shown in the table.

Time, t (in seconds)	0	5	10	20	25
Height, h (in feet)	0	12	16	19	18

Which value represents x ? _____

Which value represents y ? _____

Does time change in a constant pattern?

Does height change in a constant pattern?

Is the rate of change constant? _____

Is this a linear relationship? _____

Use what you know about functions to solve these problems.

- 1 Circle the equation that represents a linear function.

$$y = \sqrt{x + 2}$$

$$3x + 4y^2 = 9$$

$$y = \frac{x}{6} + 2$$

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

- 2 Find the slope and y -intercept for the function $y = \frac{2}{3}x - \frac{1}{2}$.

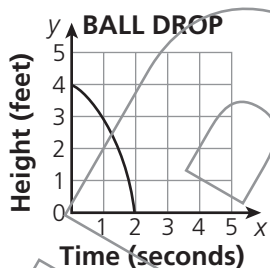
Solve the following problems.

- The Kirk family rents a motorboat while on vacation. They have to pay a non-refundable fee of \$50 plus \$15 per hour. Write an equation to describe the total amount the Kirk family will pay (y) for the total number of hours (x).

Determine the rate of change and the y -intercept.

Answer _____

- The height of a ball dropped from 4 feet is shown in the graph.

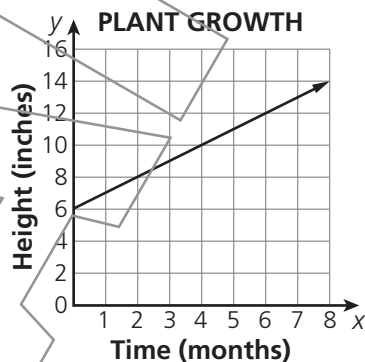


Look at the shape of the graph. Does it change at a constant rate?

Does this graph show a linear relationship?

Answer _____

- This graph shows the relationship between the height of a plant, in inches, and the time, in months, that it grows.



Think about how the graph relates to real life.

What does the slope of the graph represent?

Answer _____

Solve the following problems.

- 1** The formula $F = 1.8C + 32$ converts a temperature in Celsius to the temperature in Fahrenheit.

Part A Which value represents the rate of change, or slope?

Answer _____

Part B What is the temperature in Fahrenheit when the temperature in Celsius is 0° ?

Answer _____ $^\circ$

Part C Complete the table to find the Fahrenheit temperature at the given Celsius temperature.

$^\circ\text{C}$	-20	-10	0	25	50
$^\circ\text{F}$					

Part D Is this relationship linear? Explain how you know.

- 2** Determine which table represents a linear relationship.

A

x	1	3	5	7	9
y	1	9	25	49	81

B

x	0	1	2	3	4
y	1.5	4.5	7.5	10.5	13.5

C

x	2	5	8	11	20
y	10	15	19	60	50

D

x	1	4	25	49	100
y	1	2	5	7	10

- 3** This function table shows the relationship between the number of hours, h , an auto mechanic works to repair a car and the total cost, C , in dollars, the mechanic charges.

h	$C(\$)$
1	110
2	170
3	230
4	290

Part A Write an equation that models this relationship. Explain how you found your answer.

Part B What is the value of C , in dollars, when $h = 2\frac{1}{4}$? Explain how you know.

- 4** Match the equations from the box with the correct description. You will not use all the equations.

$y - 15x = 0$	$15y = x$	$y = 150 + 50x$	$y = 150x + 50$
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Description	Equation
Leonard makes \$15 an hour.	
Alexander has \$150 and plans to save \$50 per month.	

5 Which table of values matches the equation $y = -x + 3$?

A

x	y
2	-1
4	1
6	3
8	5

B

x	y
2	1
4	-1
6	-3
8	-5

C

x	y
2	5
4	7
6	9
8	11

D

x	y
2	-5
4	-7
6	-9
8	-11

6 What is the slope of a line that passes through the points (2, 5) and (9, 26)?

Answer _____