

Graphing Linear Equations: math lesson, Grade 8 – download the PDF

A hot-air balloon sinking at a steady speed, a savings account that grows by the same amount each week, a taxi meter that adds a fixed price per mile: behind each of these stories hides a straight line. In this chapter you will learn to read, draw, and write the equations of those lines.

1. What is a linear equation?

A **linear equation** in two variables is an equation whose graph in the coordinate plane is a straight line. Every point on that line is an **ordered pair** (x, y) that makes the equation true, and every ordered pair that makes it true lies on the line. The line goes on forever in both directions, so we draw arrowheads at its ends.

Two numbers decide everything about a line: how *steep* it is and where it *crosses the y-axis*. The next sections explain both ideas.

Why is this so useful? Because a line lets you **predict**. Once you know the equation, you can find y for any x without drawing anything, and you can also read the graph to estimate values that are not in a table. Linear models appear in budgets, travel times, recipes, and science experiments.

2. Slope-intercept form

D Slope-intercept form

A linear equation written as

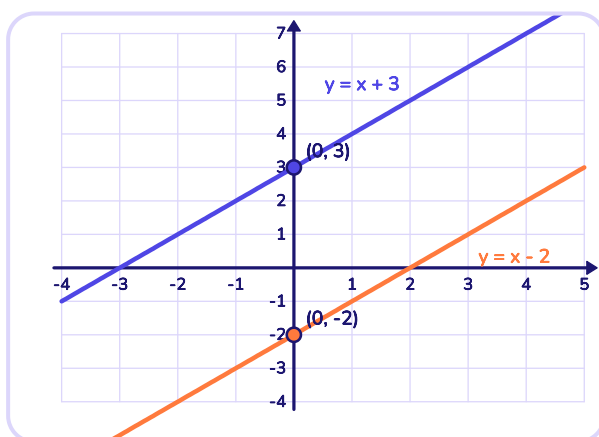
$$y = mx + b$$

is in **slope-intercept form**. The number m is the **slope** of the line and the number b is its **y-intercept**.

In $y = 3x + 5$, the slope is $m = 3$ and the y-intercept is $b = 5$. In $y = \frac{1}{2}x - 4$, the slope is $\frac{1}{2}$ and the y-intercept is -4 , because subtracting 4 means adding -4 . The equation $y = -x$ has slope -1 and y-intercept 0 .

3. The y-intercept

The **y-intercept** is the point where the line crosses the y-axis. On the y-axis the value of x is 0 , so substituting $x = 0$ into $y = mx + b$ gives $y = b$. The y-intercept is therefore the point $(0, b)$.



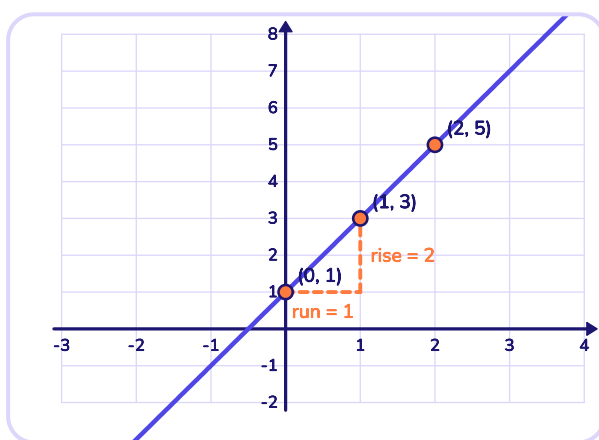
The two lines above have the same slope, 1 , but different y-intercepts, so one is simply the other shifted down 5 units.

4. Slope: rise over run

The **slope** measures how much y changes when x increases by 1. Between two points (x_1, y_1) and (x_2, y_2) on a line:

P Slope formula

$$m = \frac{\text{rise}}{\text{run}} = \frac{y_2 - y_1}{x_2 - x_1} \quad (x_1 \neq x_2)$$



- If $m > 0$, the line goes up from left to right.
- If $m < 0$, the line goes down from left to right.
- The larger $|m|$ is, the steeper the line is.

E Example 1: finding a slope

Find the slope of the line through $(-1, 5)$ and $(3, -3)$.

$$m = \frac{-3 - 5}{3 - (-1)} = \frac{-8}{4} = -2$$

The line falls 2 units each time it moves 1 unit to the right.



Watch the order

Subtract the coordinates in the *same order* on top and on the bottom. Computing $y_2 - y_1$ over $x_1 - x_2$ gives the opposite sign by mistake.

5. Graphing from a table

A table of values describes a line when y changes by the **same amount** each time x changes by the same amount. That constant change is the slope. The value of y when $x = 0$ is the y -intercept.



Example 2: from a table to a line

Here is a table of values:

x	-2	0	2	4
y	5	3	1	-1

When x goes up by 2, y goes down by 2 every time, so the rate of change is constant:

$m = \frac{-2}{2} = -1$. The table shows $y = 3$ when $x = 0$, so $b = 3$. The equation is $y = -x + 3$. To graph it, plot the four points and draw the line through them.

If the points of a table do *not* lie on one straight line, the relationship is not linear and no equation of the form $y = mx + b$ can describe it. Always test at least three pairs of values before you decide.

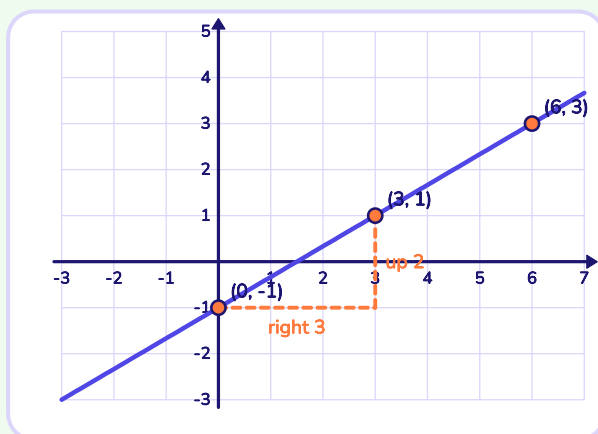
6. Graphing from an equation

M Method: graph $y = mx + b$

1. Make sure the equation is in the form $y = mx + b$.
2. Plot the y-intercept $(0, b)$.
3. Write the slope as a fraction $\frac{\text{rise}}{\text{run}}$. From the y-intercept, move up or down by the rise, then right by the run, and plot a new point.
4. Repeat once more to get a third point, which acts as a check.
5. Draw a straight line through the points and add arrowheads.

E Example 3: graph $y = \frac{2}{3}x - 1$

The y-intercept is $(0, -1)$. The slope $\frac{2}{3}$ means up 2 and right 3. From $(0, -1)$ we reach $(3, 1)$, then $(6, 3)$.



Always verify the result: choose one more value of x , compute y with the equation, and see whether the point you get is on your drawn line. If it is not, look for a sign error in the slope or in the intercept. A negative slope such as $-\frac{3}{2}$ can be read as $\frac{-3}{2}$ (down 3, right 2) or as $\frac{3}{-2}$ (up 3, left 2): both reach points of the same line.



Zyro's tip

On my home planet we say the run is the *walk* and the rise is the *climb*. A negative rise means you walk downhill. Always walk first to the right, then climb or descend!

7. Writing an equation from a graph



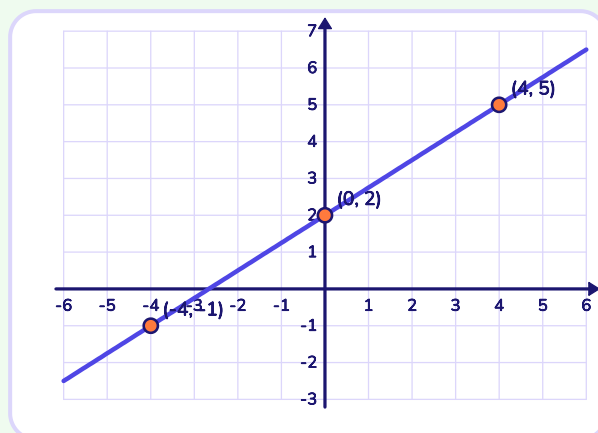
Method: read the equation of a line

1. Find where the line crosses the y-axis: this is b .
2. Pick a second point where the line passes exactly through a grid corner.
3. Count the rise and the run from one point to the other to get m .
4. Write $y = mx + b$ and test it with a third point.

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Example 4: reading a graph

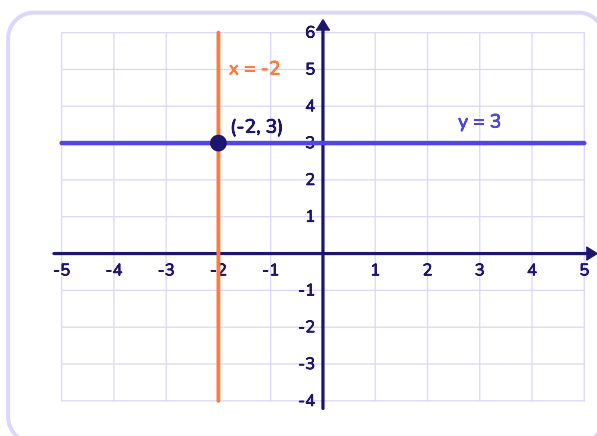
The line below crosses the y-axis at $(0, 2)$ and passes through $(4, 5)$.



From $(0, 2)$ to $(4, 5)$ the rise is **3** and the run is **4**, so $m = \frac{3}{4}$. The equation is $y = \frac{3}{4}x + 2$. Check with $(-4, -1)$: $\frac{3}{4}(-4) + 2 = -3 + 2 = -1$. It works.

8. Horizontal and vertical lines

A **horizontal line** never rises or falls, so its slope is **0**. Its equation is $y = b$: every point has the same y-coordinate. A **vertical line** goes straight up and down. Its run is **0**, and dividing by **0** is impossible, so its slope is **undefined**. Its equation is $x = a$: every point has the same x-coordinate. A vertical line cannot be written in slope-intercept form.





Do not mix them up

The equation $y = 3$ is a *horizontal* line that passes through $(0, 3)$. The equation $x = 3$ is a *vertical* line that passes through $(3, 0)$. Ask yourself which variable stays fixed.

9. Real-world linear models

In a word problem about a steady change, the slope is the **rate of change** (change per unit of time or per item) and the y-intercept is the **starting value** (the value when $x = 0$). A rate that decreases gives a negative slope.

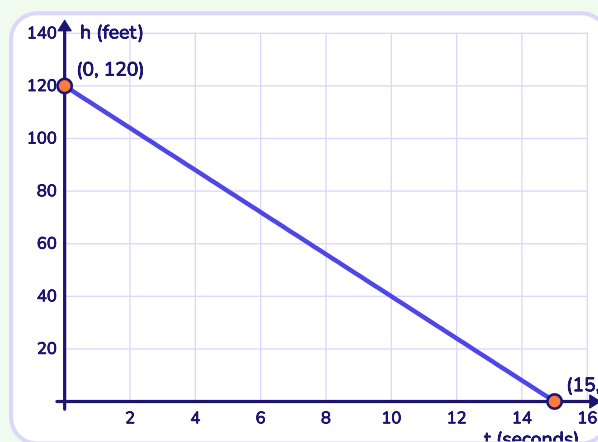
Before you write a model, ask three questions. What is changing (the output y)? What does it depend on (the input x)? How much does y change when x increases by 1, and what is y when $x = 0$? The answers give m and b directly. Always include units in your final sentence, such as dollars, feet, or gallons, and check that the answer makes sense in the story (a height cannot be negative).

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Example 5: a descending balloon

A hot-air balloon is 120 feet above the ground and descends 8 feet every second. Write a model and find when it lands.

Let t be the time in seconds and h the height in feet. The starting value is 120 and the rate is -8 , so $h = -8t + 120$. The balloon lands when $h = 0$: $-8t + 120 = 0$, so $t = 15$. It lands after 15 seconds. In meters, the starting height is about 36.6 m, because 1 foot is 0.3048 m.



Key takeaways

- The graph of $y = mx + b$ is a straight line with slope m and y-intercept $(0, b)$.
- Slope = $\frac{\text{rise}}{\text{run}} = \frac{y_2 - y_1}{x_2 - x_1}$: positive means rising, negative means falling.
- To graph a line, plot $(0, b)$, then use the slope to find more points.
- A table is linear when y changes by a constant amount for equal steps in x .
- To write an equation from a graph, read b first, then count the rise and the run.
- Horizontal lines are $y = b$ (slope 0); vertical lines are $x = a$ (undefined slope).
- In a real-world model, the slope is the rate of change and b is the starting value.



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