Imagine a warehouse dashboard showing the number of packages scanned by the end of each hour. At 9:00 a.m., the total is 18. At 10:00 a.m., it is 25. A line graph might connect those points with a smooth-looking segment. But that segment suggests the total rose continuously—and perhaps steadily—from 18 to 25 during the hour. If the packages were recorded in individual scans, that smooth story may be more than the data can support.

A step graph can tell the story more honestly. It shows a quantity staying at one level, then changing when a recorded event or update occurs. The graph's flat stretches and **discrete jumps** help preserve event timing and avoid showing **no fake in-between change**.

Before doing any math, ask: **What are the units?** Are we counting packages, measuring dollars, recording liters, or tracking some other quantity? Units help readers distinguish a total from a rate and understand what a graph actually represents.

First, Say What the Graph Measures

"The packages went up" is not precise enough to graph. Before choosing a graph type, define the recorded quantity and its timing. Is the value the number of packages scanned so far, the number scanned during the last hour, or the scanning rate in packages per hour? Those are different quantities, even if a dashboard happens to show all three.

Here is a useful example rewritten as one clean sentence:

Clean sentence: "The graph shows the cumulative number of packages recorded by the scanner, beginning at 9:00 a.m.; a package is added to the total when its scan is recorded."

This sentence identifies the quantity (a cumulative count), the start time (9:00 a.m.), and what causes the value to change (a recorded scan). It also signals that packages are discrete items. The total usually stays the same between scans and jumps when one or more scans are added.

Define the start time and the recording rule

A cumulative total needs a starting point. If the count begins at 9:00 a.m., does it include packages scanned exactly at 9:00? Does the graph show the total just before or just after an event recorded at that time? For everyday dashboard reading, these choices may seem small. For precise interpretation, they matter.

For example, "packages scanned since 9:00 a.m." could mean the total starts at zero at 9:00 and then increases with later scans. A count labeled "packages scanned by 9:00 a.m." might already include earlier work. State the rule so readers can tell what a value means.

Totals and Rates Answer Different Questions

A **total** answers, "How much has accumulated?" A **rate** answers, "How quickly is it accumulating over a specified interval?" A total is not a rate, even when the total changes over time.

For the package example:

- **Cumulative total:** 25 packages recorded by 10:00 a.m.
- **Interval total:** 7 packages recorded from 9:00 to 10:00 a.m.
- **Average rate during the interval:** 7 packages per hour.

The average rate comes from a change in the total divided by an elapsed time. If $C(t)$ is the cumulative package count at time t, then between times t_1 and t_2, the average rate of change is

$$\frac{C(t_2)-C(t_1)}{t_2-t_1}.$$

The numerator is a change in packages; the denominator is a change in time. If the interval is one hour and the count increases by 7 packages, the average rate is 7 packages per hour. The unit makes the answer interpretable. “Seven” alone could mean seven packages, seven packages per hour, or something else.

Notice the word *average*. The calculation summarizes the whole interval. It does not say that packages arrived at a steady pace throughout the hour. If all seven packages were scanned in one short burst, the average rate is still 7 packages per hour for that hour—but a claim that the scanner recorded 7 packages every hour, or continuously at that pace, would be unsupported.

Why a Straight Line Can Tell a False Story

A line segment between two data points is not merely decoration. It makes a visual claim about what happened between them. If the cumulative count is 18 at 9:00 and 25 at 10:00, a straight connection suggests that the count changed gradually at a constant rate between those timestamps.

That could be a reasonable model if the quantity genuinely changes continuously, or if the data represent an average over the interval and the graph is explicitly meant to show that average. But if the count changes only when individual packages are scanned, the straight segment invents intermediate values and timing. It may suggest 21.5 packages at some point, even though a package count cannot be half a package. More importantly, the data may not tell us when the seven scans occurred.

A step graph instead shows a horizontal segment at 18, then a jump to 25 when the update is recorded. It communicates that the recorded cumulative total did not change between updates—or, more carefully, that the available records show no change during that span.

“No change recorded” is not always “nothing happened”

Honesty also means not claiming more than the data establish. Suppose a system stores a count only once an hour. A flat segment from 9:00 to 10:00 may mean the displayed value was held constant until the next update. It does not necessarily prove that no packages were scanned during the hour. They might have been scanned continuously but entered into the dashboard in a batch at 10:00.

So explain the recording process. A step graph preserves the timing of *recorded updates*. It preserves the timing of real-world events only when the records actually capture when those events occurred. If event times are unknown, show that uncertainty rather than letting a graph imply precision the data do not have.

Intervals Matter When You Calculate Average Rate

Rates belong to intervals. “The average rate was 7 packages per hour” is incomplete unless the interval is clear. Was that from 9:00 to 10:00? From 9:30 to 10:30? From the beginning of a shift to its end? The same total change can produce different average rates over different time spans.

Suppose the cumulative count rises from 18 at 9:00 to 25 at 10:00. The interval change is 7 packages over 1 hour, so the average rate is 7 packages per hour. If the same increase occurred over 30 minutes, the average rate would be 14 packages per hour. The change in total is the same; the elapsed time is not.



Keep units consistent. If timestamps are given in minutes but the requested rate is per hour, convert the interval before dividing. For example, 30 minutes is \(0.5\) hours, not 30 hours. Then \(7 \div 0.5 = 14\) packages per hour. Labeling both axes helps prevent this kind of mix-up: time in hours on the horizontal axis and cumulative packages on the vertical axis.

Question Quantity to use Example unit How many packages had been recorded by 10:00? Cumulative total packages How many packages were recorded from 9:00 to 10:00? Change in the cumulative total packages What was the average scanning rate from 9:00 to 10:00? Change divided by elapsed time packages per hour

How to Read and Explain a Step Graph

When you introduce a step graph, describe what the horizontal parts and jumps mean. A clear explanation might be:

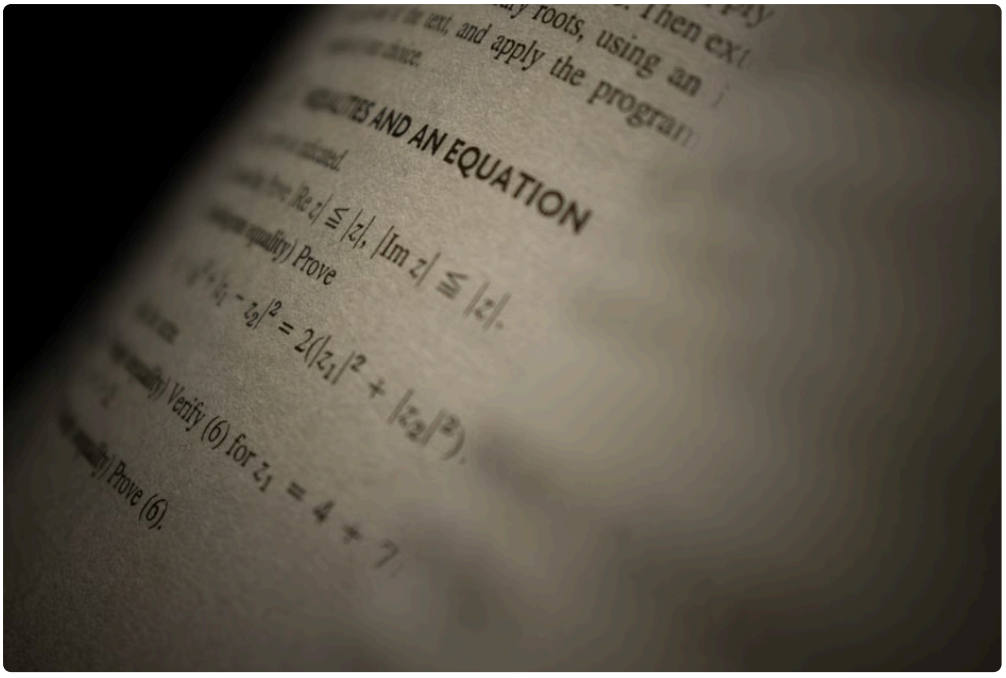
"The vertical axis shows the cumulative number of packages recorded, in packages. The horizontal axis shows time, in hours. The count stays at its recorded level between updates and jumps when the system records additional packages. The graph shows the timing of recorded changes, not a constant rate between them."

This explanation distinguishes the total from its rate and makes the graph's limits visible. If the jump is at 10:00, explain whether it represents packages scanned exactly at 10:00 or a batch reported at that time. A graph's endpoint convention can affect which value readers assign at the exact moment of a jump. For introductory communication, a note beside the graph is often enough; in technical work, specify the convention.

1. **Name the quantity.** Say whether it is a cumulative total, an interval count, a balance, or a rate.
2. **Give the units.** Label time and the measured quantity, including compound units such as dollars per day.
3. **State the start time.** Explain when counting begins and what the initial value includes.
4. **Explain when values update.** Identify whether jumps reflect actual event times, scheduled readings, or batch updates.
5. **Use intervals for average rates.** Give both endpoints and divide the change in quantity by the elapsed time.

Where Step Graphs Help—and Where They Do Not

Step graphs are especially useful for cumulative counts, inventory levels updated after transactions, account balances updated after posted transactions, and other quantities that remain fixed between discrete changes. A step graph can show a stock of inventory staying at 120 units until a shipment arrives, then jumping to 170 units. The graph does not imply that half a shipment arrived at an arbitrary point between recorded times.



Still, the graph type should fit the process and the data. A temperature measured continuously is not usually best represented as a sequence of jumps simply because readings were taken every hour. A smooth line may be a reasonable way to model changes between measurements, provided readers understand that the intermediate values are estimates. Conversely, a step graph may be misleading if the quantity changes continuously and the flat sections are read as proof that it did not.

Ask two questions: What is the real-world quantity doing? And what does the recording system actually know? A good graph respects both. If the event time is known, place the jump accordingly. If it is only known that an update happened sometime during an hour, show or explain that uncertainty instead of choosing an exact time without evidence.

Using MathJax and Runestone to Teach the Idea

MathJax can render the average-rate formula clearly in a web lesson, alongside the units students need to interpret it. For example, show the quotient and then substitute the package-count change and https://activecalculus.org/author/Running-Totals-Rates-of-Change elapsed time. Keep the labels visible: \(7\text packages/1\text hour=7\text packages per hour\). The equation is more useful when learners can see what each number measures.

Runestone, an interactive publishing platform, can support a lesson in which learners compare a line graph and a step graph for the same event log. Ask them to identify what each graph claims between timestamps, select the correct interval for an average-rate calculation, or explain why a displayed total is not itself a rate. An interactive prompt can also ask learners to label the axes and specify the start time before interpreting the graph.

The teaching goal is not “step graphs are always better.” It is to match the visual story to the event and the evidence. When values change in discrete updates, a step graph often preserves event timing better than a

connecting line. It shows what is recorded, avoids invented intermediate changes, and gives readers a clearer basis for asking the next question: Is this a total, a change over an interval, or a rate?