# Negative Rates

Let's apply what we know about signed numbers.

## 12.1 Shirts per Minute

1. If you fold 5 shirts per minute for 8 minutes, how many shirts will you fold?

2. If you hear 9 new songs per day for 3 days, how many new songs will you hear?

3. If you run 15 laps per practice, how many practices will it take you to run 30 laps?


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# 12.2 Water Level in the Aquarium

1. A large aquarium should contain 10,000 liters of water when it is filled correctly. It will overflow if it gets up to 12,000 liters. The fish will get sick if it gets down to 4,000 liters. The aquarium has an automatic system to help keep the correct water level. If the water level is too low, a faucet fills it. If the water level is too high, a drain opens.

   One day, the system stops working correctly. The faucet starts to fill the aquarium at a rate of 30 liters per minute, and the drain opens at the same time, draining the water at a rate of 20 liters per minute.

   a. Is the water level rising or falling? How do you know?

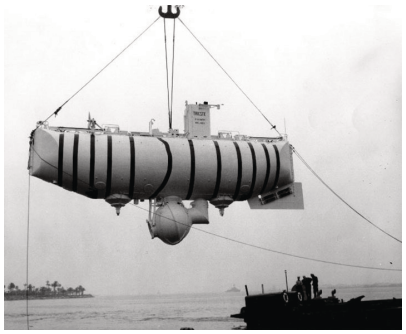
   b. How long will it take until the tank starts overflowing or the fish get sick?

2. A different aquarium should contain 15,000 liters of water when filled correctly. It will overflow if it gets to 17,600 liters.

   One day there is an accident, and the tank cracks in 4 places. Water flows out of each crack at a rate of $\frac{1}{2}$ liter per hour. An emergency pump can re-fill the tank at a rate of 2 liters per minute. How many minutes must the pump run to replace the water lost each hour?

# 12.3 Up and Down with the Piccards

1. Challenger Deep is the deepest known point in the ocean, at 35,814 feet below sea level. In 1960, Jacques Piccard and Don Walsh rode down in the *Trieste* (tree-EST) and became the first people to visit the Challenger Deep.



   a. The *Trieste* descended at a rate of -3 feet per second. We can represent this as $y = -3x$, where $y$ is the depth (in feet) and $x$ is the time (in seconds). Using this model, how much time would the *Trieste* take to reach the bottom?

   b. It took the *Trieste* about 3 hours to ascend back to sea level. This can be modeled by a different equation $y = kx$. What is the value of $k$ in this situation?

2. The design of the *Trieste* was based on the design of a hot air balloon built by Auguste Piccard, Jacques's father. In 1932, Auguste rode in his hot-air balloon up to a record-breaking height.

   a. Auguste's ascent took 7 hours and went up 51,683 feet. Write an equation $y = kx$ to represent his ascent from his starting location.

   b. His descent took 3 hours and went down 52,940 feet. Write another equation to represent his descent.

   c. Did Auguste Piccard end up at a greater or lesser altitude than his starting point? How much higher or lower?

## Are you ready for more?

During which part of either trip was a Piccard changing vertical position the fastest? Explain your reasoning.

A. Jacques's descent

B. Jacques's ascent

C. Auguste's ascent

D. Auguste's descent

## Lesson 12 Summary

We saw earlier that we can represent speed with direction using signed numbers. Speed with direction is called *velocity*. Positive velocities always represent movement in the opposite direction from negative velocities.

We can do this with vertical movement: Moving upward can be represented with positive numbers, and moving downward with negative numbers. The magnitude tells you how fast, and the sign tells you which direction. (We could actually do it the other way around if we wanted to, but usually we represent movement upward with positive numbers and movement downward with negative numbers.)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