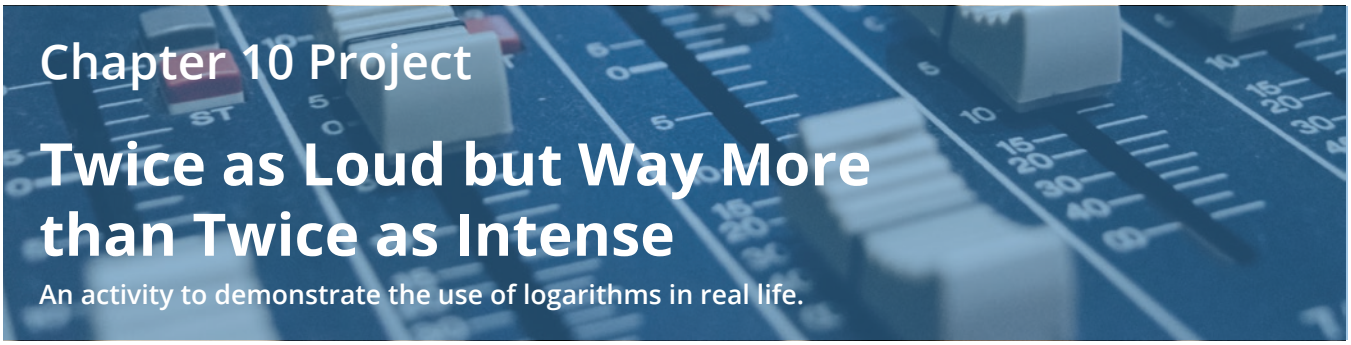

Chapter 10 Project

Twice as Loud but Way More than Twice as Intense

An activity to demonstrate the use of logarithms in real life.

In this chapter you have learned about logarithms and their properties. In this activity, you will explore applications of logarithms within physics and chemistry.

1. In chemistry, the acidity of a substance is measured using its pH. More acidic solutions have a lower pH and more alkaline solutions have a higher pH. The formula for the pH is given by $\text{pH} = -\log\left[\text{H}^+\right]$ where $\left[\text{H}^+\right]$ is the hydrogen ion concentration in moles per liter. The smaller the value of $\left[\text{H}^+\right]$, the larger the pH.

- **a.** Pure water is considered a neutral substance. Compute the pH of water knowing that $\left[\text{H}^+{}_{\text{water}}\right] = 10^{-7}$.
- **b.** Bleach is a very alkaline solution. Compute the pH of bleach knowing that $\left[\text{H}^+{}_{\text{bleach}}\right] = 10^{-11}$.
- **c.** How many times is the pH of bleach larger than the pH of water? (**Hint:** divide the pH of bleach by that of water.) Round to the nearest tenth.
- **d.** How many times is the concentration of hydrogen ions in water larger than the concentration of hydrogen ions in bleach?
- **e.** Find an example of an acidic substance; that is, find a substance with pH less than 7. Use its pH to compute its hydrogen ion concentration $\left[\text{H}^+\right]$.
- **f.** For any natural number k suppose there is a substance for which $\left[\text{H}^+\right] = 10^{-k}$. Explain why this substance would have a pH equal to k.
- **g.** Explain why smaller values of $\left[\text{H}^+\right]$ yield larger pH values.

2. The more energy a sound wave carries, the louder the wave sounds to a listener. For a wave with intensity I_{wave}, measured in watts per square meter (W/m^2), its loudness L_{wave} in decibels (dB) is given by the equation

$$L_{\text{wave}} = 10\log\left(\frac{I_{\text{wave}}}{I_0}\right),$$

where I_0 is a constant equal to 10^{-12} W/m^2.

- **a.** What is the loudness in decibels of normal conversation, knowing that it has intensity $I_{\text{conversation}} = 10^{-6}$?
- **b.** Busy traffic is about 72 dB. How many times is busy traffic louder than normal conversation? In other words, how many times is L_{traffic} larger than $L_{\text{conversation}}$?
- **c.** How many times is busy traffic more intense than normal conversation? In other words, how many times is I_{traffic} larger than $I_{\text{conversation}}$? Round to the nearest tenth.
- **d.** A 60 dB sound is twice as loud as a 30 dB sound. Is it correct to say that a 60 dB sound is twice as intense as a 30 dB sound? Explain.