Chapter 4 Project

What Do Exponents and Earthquakes Have in Common?

An activity to investigate the Richter magnitude scale for seismic activity.

People living along the San Andreas fault in Southern California are aware that the "big one" is coming. According to scientists, there is a 72% probability of a 6.7 or larger magnitude earthquake hitting the San Francisco Bay area by the year 2043.[1]

In this project, you will investigate the meaning of an earthquake's magnitude.

In 1935, Charles Richter proposed a scale to measure the magnitude M of an earthquake according to a formula equivalent to

$$10^M = \frac{I}{S}.$$

In this formula, I is the intensity of the earthquake in question and S is the intensity of a standard earthquake. For example, if an earthquake has an intensity 10 times that of a standard earthquake ($I = 10S$), then its Richter magnitude scale is the solution to the equation

$$10^M = \frac{10S}{S}.$$

We can cancel the S in the numerator and denominator and see that that $10^M = 10$, and we get $M = 1$.

1. Use the formula $10^M = \frac{I}{S}$ to complete the following table. Note that the value before S indicates how many times more intense the earthquake is compared to a standard earthquake.

Earthquake Intensity (I)	Richter Magnitude Scale (M)
S	
$10S$	1
$100S$	
$1000S$	
$10{,}000S$	
$100{,}000S$	

2. By what factor must the intensity of an earthquake increase by in order for the Richter magnitude scale to increase by one point? (This type of scale is called a *logarithmic* scale and allows very large intensities to be compared by relatively small magnitudes.)

3. Consider two earthquakes, one of magnitude 6.2 and another of magnitude 4.7. How many times more intense is the stronger earthquake than the weaker one? (**Hint:** Would you compare the earthquakes to a standard earthquake or to each other?)

1 "The San Andreas Fault: Is the Big One Coming?" How Stuff Works, last modified July 16, 2019, https://science.howstuffworks.com/nature/natural-disasters/san-andreas-fault.

4. How many times more intense would the "big one" be than the standard earthquake? Recall that the big one has $M = 6.7$.

Similarly, you can measure the intensity of a sound wave relative to that of a standard sound wave. The number B of decibels (dB) for a particular sound is found by solving the equation

$$10^{B/10} = \frac{I}{S},$$

where I is the intensity of the sound in question and S the intensity of a standard sound.

5. A jet engine produces 120 dB of sound, which is the threshold for pain and permanent hearing loss, while a quiet room is about 40 dB. How many times more intense is the sound of a jet engine than a quiet room?