

More Applications of Exponential Equations

$$\text{Earthquake Intensity} \rightarrow I = 10^{R_f - R_o}$$

1. The intensity of an earthquake is understood as the strength in the shaking produced. On April 10, 2023, at 3:54am, there was an earthquake with a magnitude of 4.7. In 1960, Chile experienced an earthquake with magnitude of 9.5. How many times more intense what the earthquake in 1960 than the one last week?
2. How many times more intense is an earthquake with a magnitude of 7.7 (Turkey) compared with one with a magnitude of 4.4 [Vancouver Island 2018]?
3. Suppose a recent earthquake was three times more intense that the recent earthquake of magnitude 4.7 in Chile. What is the magnitude on the Richter scale of this earthquake?
4. Earthquakes are also measured in Magnitudes, a measure of the amount of energy released at the source of the earthquake. For each increase in magnitude on the Richter scale, the amount of energy released will increase by 32 times. Scientists predict that a megathrust quake with the Juan de Fuca plate near western BC within the next 100 to 150 years. How much more energy will this earthquake release compared to the recent 4.7 in Chile?
5. In 1935, American seismologist Charles R. Richter developed a scale formula for measuring the magnitude of earthquakes. The Richter magnitude, M , of an earthquake is defined as $M = \log \frac{A}{A_0}$, where A is the amplitude of the ground motion, usually in microns, measured by a sensitive seismometer, and A_0 is the amplitude, corrected for the distance to the actual earthquake, that would be expected for a “standard” earthquake.
 - In 1946, an earthquake struck Vancouver Island off the coast of British Columbia. It had an amplitude that was 107.3 times A_0 . What was the earthquake’s magnitude on the Richter scale?
 - The strongest recorded earthquake in Canada struck Haida Gwaii, off the coast of British Columbia, in 1949. It had a Richter reading of 8.1. How many times as great as A_0 was its amplitude?
 - In 1812, an earthquake of magnitude 7.9 shook New Madrid, Missouri. How many times more intense was the New Madrid earthquake compared to the 2001 earthquake of magnitude 3.2 in Charlottesville, Virginia?

$$\text{Sound Intensity} \rightarrow I = 10^{\frac{D_f - D_o}{10}}$$

6. A research was conducted to test the noise levels in restaurants. Acceptable noise levels for conversations range from 40 to 75db. How many times louder is noise at 75db compared to 40db?

7. Noise levels at 110db or more can damage your hearing if exposed for long periods of time. Exposure at 90db for 8 hours or less is acceptable. For every increase in 5 db, the acceptable exposure time is reduced by half.
 - a) What is the acceptable exposure time for a loud concert at 115db?
 - b) What is the acceptable exposure time for a loud argument at 100db?
 - c) What is acceptable exposure time when swimming next to a sperm whale that is clicking at 233 db?
8. One brand of ear plugs claims to block the sound of snoring as loud as 22 dB. A second brand claims to block snoring that is eight times as intense. If the claims are true, for how many more decibels is the second brand effective?
9. Scientists have found that the sensation of loudness can be described using a logarithmic scale. The intensity level, in decibels, of a sound is defined as $L_{dB} = 10 \log \frac{I}{I_0}$, where I is the intensity of the sound, in watts per square metre and I_0 is 10^{-12} W/m², corresponding to the faintest sound that can be heard by a person of normal hearing. What is the measure of the loudness, in decibels of a hair dryer that has an intensity of 10^{-5} ?

$$\text{pH} \rightarrow [H^+] = (10)^{-\text{pH}}$$

10. The pH of lemon juice is 2.3 while the pH of milk is 6.6. Determine the concentration of hydrogen ions in each substance using the formula $\text{pH} = -\log[H^+]$. Which substance is more acidic?
11. The concentration of hydrogen ions in apple juice can be written as $[H^+] = 3.2 \times 10^{-4}$. Use the formula $\text{pH} = -\log[H^+]$ to determine the pH of apple juice.

The Palermo Scale

12. The Palermo Technical Impact Hazard scale was developed to rate the potential hazard impact of a near-Earth object. The Palermo scale, P, is defined as $P = \log R$, where R is the relative risk. Compare the relative risks of two asteroids, one with a Palermo scale value of -1.66 and the other with a Palermo scale value of -4.83.

The Krumbein Phi Scale

13. The Krumbein phi scale is used in geology to classify sediments such as silt, sand, and gravel by particle size. The scale is modelled by the function $D = 2^{-\phi}$, where D is the diameter of the particle, in millimetres, and ϕ is the Krumbein scale value. Fine sand has a Krumbein scale value of approximately 3. Coarse gravel has a Krumbein scale value of approximately -5.
 - Why does a coarse material have a negative scale value?
 - How does the diameter of fine sand compare with the diameter of coarse gravel?