Can You Hear Me Now?

ID: 12367

Time Required
15–20 minutes

Activity Overview

In this activity, students will explore logarithmic equations relating to sound intensity and pH.

Topic: Logarithmic Equations

- *Logarithmic Equations*
- *Sound Intensity (decibels)*
- *pH*
- *Inverse Functions (Exponential Functions)*

Teacher Preparation and Notes

- *The first problem engages students in an activity which explores the logarithmic relationship between the power of sound in $\frac{W}{m^2}$ and its intensity decibels (dB). Analysis is performed using both a function graph and spreadsheet functionality.*
- *A second problem involving pH is available for use either as an in-class extension or for assigning as homework.*
- ***To download the student and solution TI-Nspire documents (.tns files) and student worksheet, go to education.ti.com/exchange and enter "12367" in the quick search box.***

Associated Materials

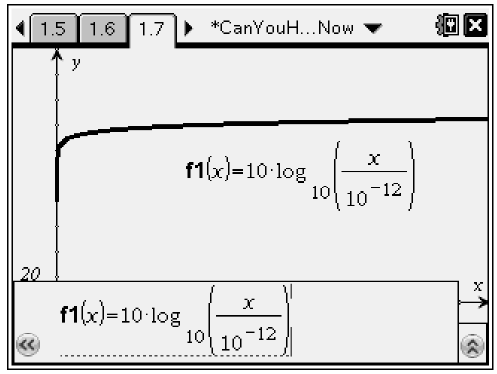
- *CanYouHearMeNow_Student.doc*
- *CanYouHearMeNow.tns*
- *CanYouHearMeNow_Soln.tns*

Suggested Related Activities

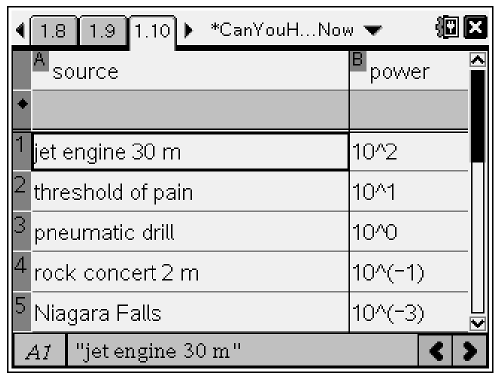
To download any activity listed, go to education.ti.com/exchange and enter the number in the quick search box.

- *Orders of Magnitude (TI-Nspire technology) — 9706*
- *Properties of Logarithms (TI-Nspire technology) — 9607*
- *Evaluating Logarithms (TI-Nspire technology) — 9533*

Problem 1 – Intensity of Sound

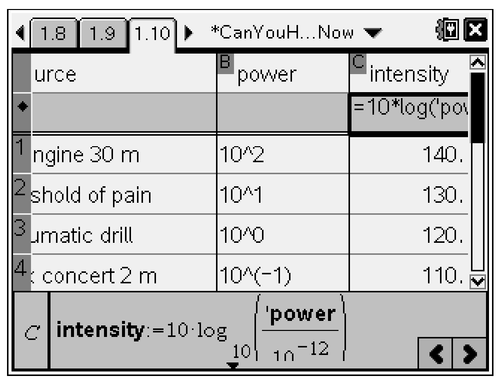


In this problem, students first explore intensity of sound in decibels when given power in $\frac{W}{m^2}$. Students will graph the equation $\beta = 10\log\left(\frac{I}{I_0}\right)$, make a sketch of the graph and describe the observed pattern. Students then apply the equation in a spreadsheet to calculate the sound intensity for a variety of sound sources. Students then make comparisons between various sound sources as they answer related questions.



It may be helpful to review with students that unless indicated otherwise, it is assumed that the base for the log function is 10. The default is a base of 10 when no base is typed in by the student.

This activity topic provides a great opportunity to integrate math and science education. Consider working with colleagues teaching chemistry and physics to better align instruction related to this topic for the benefit of the students.

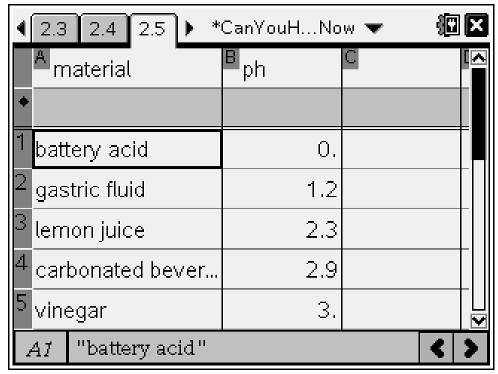


A sound intensity level of 85 dB will result in hearing loss with long term exposure as indicated on the spreadsheet. Levels higher than 85 dB will result in hearing loss with short term exposure. Discussion of the data on page 1.10 will help students better understand the questions asked of them on pages 1.12 and 1.13.

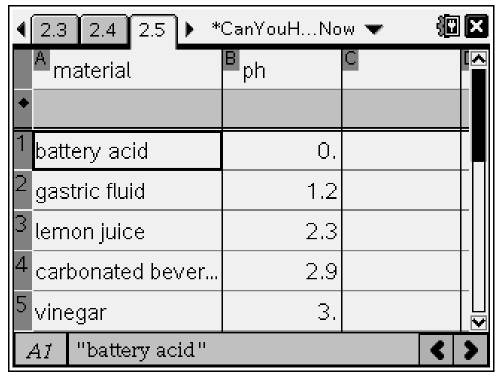
Review the inverse of a logarithmic function with students. An exponential function (inverse of the logarithmic function) will be used to answer the final question for this section. The inverse function will also be used in Problem 2 to convert pH to hydrogen ion concentration.

Problem 2 – pH

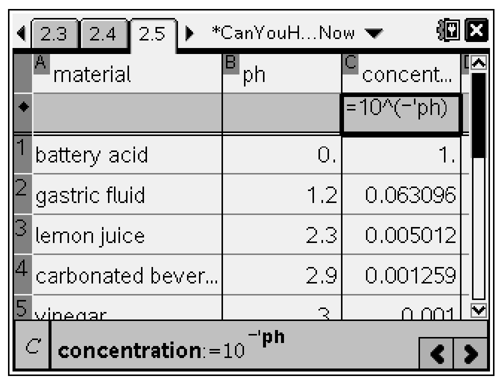
Students explore the graph of the relationship between pH and concentration, pH = –log[H^+]. This exploration is first performed graphically, then, as in the previous problem, students use a spreadsheet column to perform calculations. In this problem, students will calculate the hydrogen ion concentration of a variety of common substances for which the pH is known.



On page 2.5, students will convert given pH values for common substances to concentration of hydrogen ion, [H^+].



Note that when an equation is typed into a spreadsheet, column headings are typed in where variables would otherwise appear. When typed correctly, the linked variable column heading appears in bold as shown in the last screen shot to the right.



Student Solutions

1. Logarithmic equations are helpful in real applications whenever possible function values cover extremely large ranges.
2. β = sound intensity level in dB
   I = Intensity of sound in $\frac{W}{m^2}$
   $I_0 = 10^{-12}\ \frac{W}{m^2}$, the sound intensity of barely audible sound
3. See graph on solution TI-Nspire document.
4. As x approaches ∞, the function increases very rapidly from x = 0 to about x = 0.5, then the rate of change slows dramatically beyond this value. Negative values of x are not defined for this function. As x approaches zero from the right, the function value drops quickly to $-\infty$.
5. Niagara Falls
6. jet engine, pneumatic drill
7. 10^{-3} W*m^{-2}
8. $pH = -\log[H^+]$
9. See graph on solution TI-Nspire document.
10. As x approaches ∞, the function decreases very rapidly from x = 0 to about x = 1, then the rate of change slows dramatically beyond this value. Negative values of x are not defined for this function. As x approaches zero from the right, the function value rises quickly.
11. Negative concentrations don't make sense. You can't have less than 0 hydrogen ions and therefore can't have a negative concentration.
12. carbonated beverages
13. sea water
14. Milk is often a surprise to students because they think of it as basic. The acidity of carbonated beverages, including sodas may be a surprise and a concern. The different pH levels for rain, distilled, and sea water also are worthy of discussion.