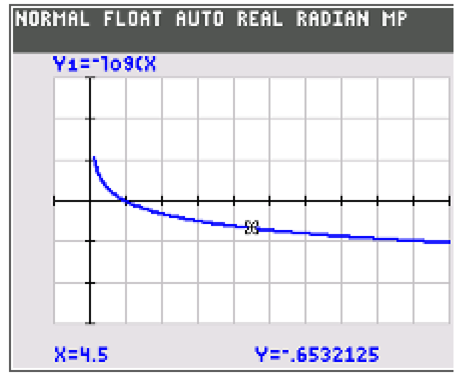
Can You Hear Me Now?

About the Lesson

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

- Explore the logarithmic relationship between the power of sound in $\frac{W}{m^2}$ and its intensity decibels (dB).
- Analyze using both a function graph and numeric calculations.



Vocabulary

- logarithms
- exponential functions

Teacher Preparation and Notes

- 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 second problem involving pH is available for use either as an in-class extension or for assigning as homework.

Activity Materials

- Compatible TI Technologies:

  TI-84 Plus*
  TI-84 Plus Silver Edition*
  TI-84 Plus C Silver Edition
  TI-84 Plus CE

***** *with the latest operating system (2.55MP) featuring MathPrint™ functionality.*

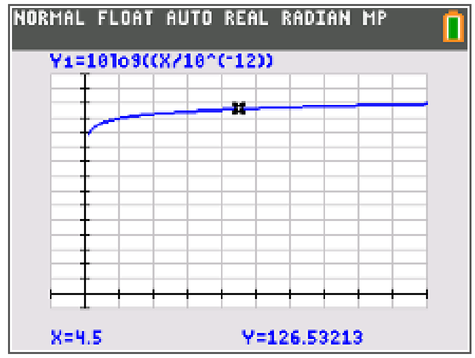
Tech Tips:

- This activity includes screen captures taken from the TI-84 Plus CE. It is also appropriate for use with the rest of the TI-84 Plus family. Slight variations to these directions may be required if using other calculator models.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials
- Any required calculator files can be distributed to students via handheld-to-handheld transfer.

Lesson Files:

- Can_You_Hear_Me_Now_Student.doc
- Can_You_Hear_Me_Now_Student.pdf

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 $\beta = 10\log\left(\frac{I}{I_0}\right)$ and describe the observed pattern.

Students then apply the equation 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. This why it is called the "common log."

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 will help students better understand the questions asked of them in this section

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.

1. Using the graph and the trace key, describe the features of this graph. (What happens to the graph as $x \to \infty$? What happens as $x \to 0$? Is the function increasing or decreasing? What happens when x is negative? Where does the function change rapidly? Where does the function change slowly?)

Answer: As $x \to \infty$, 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 $-\infty$.

Source	Power	Intensity
Jet engine (30 m away)	10^{2}	**140**
Threshold of pain	10^{1}	**130**
Pneumatic drill	10^{0}	**120**
Rock concert (2 m away)	10^{-1}	**110**
Niagara Falls	10^{-3}	**90**
Hearing damage: long term	10^{-3}	**90**
Busy traffic	10^{-5}	**70**
Normal talking (1 m away)	10^{-6}	**60**
Library	10^{-8}	**40**
Leaves rustling	10^{-11}	**10**
Auditory threshold	10^{-12}	**0**

2. Which of the following events will cause damage *only* if exposure is *long term*?

a. Normal talking

b. Niagara Falls

c. Busy traffic

d. Jet engine

Answer: Niagara Falls

3. Which of the following events listed will result in hearing loss following short-term exposure?

a. Jet engine

b. Pneumatic drill

c. Busy traffic

d. Normal talking

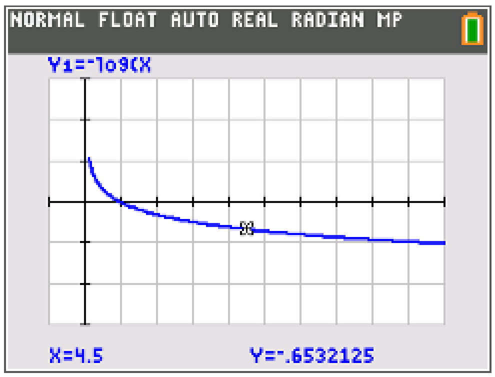
Answer: Jet engine, Pneumatic drill

4. Elevated trains, such as the "L" in Chicago, produce a great deal of noise. If the sound level recorded from one of these trains is 90 dB, use the intensity equation $\beta = 10\log\left(\frac{I}{I_0}\right)$ to find the power (I) in $\frac{W}{m^2}$.

Answer: $10^{-3} W * m^{-2}$

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 apply the equation to calculate the PH for a variety of sources. In this problem, students will calculate the hydrogen ion concentration of a variety of common substances for which the pH is known.



5. Describe the features of this graph. (What happens to the graph as $x \to \infty$? What happens as $x \to 0$? Is the function increasing or decreasing? What happens when x is negative? Where does the function change rapidly? Where does the function change slowly?)

Answer: As $x \to \infty$, 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.

6. Why do negative values of x not make sense in the context of the pH equation?

Answer: Negative concentrations do not make sense because you cannot have less than 0 hydrogen ions, and therefore can't have a negative concentration.

Source	**pH**	**$[H^+]$**
Battery acid	0	**1**
Gastric fluid	1.2	**0.06**
Lemon juice	2.3	**0.005**
Carbonated beverages	2.9	**0.001**
Vinegar	3	**0.001**
Tomato juice	4.1	**0.00008**
Coffee	5	**0.00001**
Rain water	5.8	**0.000002**
Milk	6.6	**2.5×10^{-7}**
Distilled water	7	**1.0×10^{-7}**
Sea water	8	**1.0×10^{-8}**
Milk of magnesia	10.7	**2.0×10^{-11}**
Household ammonia	11.5	**3.2×10^{-12}**
Household bleach	12.6	**2.5×10^{-13}**
Lye solution	14	**1.0×10^{-14}**

7. Which of the following substances is most acidic?

a. Vinegar

b. Tomato juice

c. Rain water

d. Carbonated beverages

Answer: Carbonated beverages

8. Which of the following is least acidic (or most basic)?

a. Sea water

b. Gastric juices

c. Milk

d. Distilled water

Answer: Sea water

9. Do any of the values listed in the table surprise you? Which ones? Why?

Sample Answer: 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.

