

8D. Logarithmic Scales: Earthquakes, Sounds, Acids

1. Why do scientists use logarithmic scales?

Answer: To make it easy to talk about quantities that are WIDELY varying in size. Earthquakes: from a mild shaking of the ground to a massive earthquake. Sound: from a whisper to a jet plane sound. pH: from strong acid, like lemon juice, to neutral, pure water, to strongly “base” like ammonia.

2. How do we interpret two successive numbers on a logarithmic scale?

Answer: Something about what the smaller is MULTIPLIED by, not what is added to it.

3. If they are logarithmic scales, what are the numbers logarithms OF?

Answer: Different things for these three different scales.

Magnitude Scale for Earthquakes.

This is essentially the Richter scale. The Richter scale is often described in terms of how much the ground shakes (<http://www.geo.mtu.edu/UPSeis/intensity.html>) with an earthquake of magnitude 5 meaning that the ground shakes 10 times as much as with an earthquake of magnitude 4.0. A more precise way of thinking of this is in terms of the energy released, and that is what the author of our book does. See the definition on page 501. So an earthquake of magnitude 5 releases 32 times as much energy as an earthquake of magnitude 4.

Activity 1: Do Exercises 10, 12, 14.

Decibel Scale for Sound.

In our text, the basic measure of loudness isn't defined. But in <http://www.physicsclassroom.com/Class/sound/u1112b.cfm> we see that the basic unit of sound intensity is watts/meter².

However, the table in our text makes it very easy to see the multiplicative relationship.

Activity 2: Look at the Decibel table. How many times more intense is a sound at the “threshold of pain for the human ear” than “ordinary conversation”? Don't use a formula. Just discuss and see if you can figure it out.

Read Examples 3 and 4. Do exercise 17.

pH scale for acidity.

The underlying measure of acidity is the concentration of hydrogen ions in a substance (in moles per liter.) The formulas for converting between hydrogen ion concentration and pH are given on page 504.

Activity 3: Read Examples 6 and 7. Do exercise 29.

A non-logarithmic scale relationship: The Inverse Square Law for Sound.

Activity 4: Read Example 5.

Exercise 21

MP's exercise: In my church, we bought a new electronic organ with big speakers. When I sit in the choir area (about 10 feet from the speakers) my ears hurt sometimes. If I don't sit there, but move to the front pew instead (another 5 feet away) how much different is the intensity of the sound? Answer this by saying how what factor the intensity has decreased by when I moved to the front pew.

Exercises 22, 24

Test 3: Covers Chapter 8. Thur. Apr. 4 – Wed. Apr. 10 in NRG Testing Center. One page of handwritten notes allowed, with no examples.

The following formulas and information will be included on a page at the end of the test.

- 8B. page 485. The exact doubling time and half-life formulas
- Page 493. The contents of the box on "Logistic Growth."
- 8D, pages 500 – 505. All three tables and the contents of all the orange boxes.

Answers to questions on this handout:

Activity 1 Answers: 10. About $32^2 = 1024$ 12. 1.8×10^{16} joules 14. $M=7.53$

Activity 2 Answer: From 60 decibels to 70 decibels is 10 times more intense, and then to 80 decibels is 10 times more intense than that, so 60 to 80 decibels is $10 \times 10 = 100$ times more intense. So from 60 to 90 decibels is 1000 times more intense.

Activity 4 MP's question. Answer: At 10 feet away, the intensity is $1/100$. At 15 feet away, the intensity is $1/225$. The distance has increased by a factor of 1.5, so the intensity has decreased by a factor of $1.5^2 = 2.25$.

Activity 4 Answers: 22. $(200)^2 = 40000$ 24. Distance has decreased by a factor of 10, so intensity of the sound will increase by a factor of $10^2 = 100$

