

## CRITIQUE & EXPLAIN

Earthquakes make seismic waves through the ground. The equation  $y = 10^x$  relates the height, or amplitude, in microns, of a seismic wave,  $y$ , and the power, or magnitude,  $x$ , of the ground-shaking it can cause.

Taylor and Chen used different methods to find the magnitude of the earthquake with amplitude 5,500.

Magnitude, $x$	Amplitude, $y$
2	100
3	1,000
?	4,500
4	10,000

**Taylor**

5,500 is halfway between 1,000 and 10,000.

3.5 is halfway between 3 and 4.

The magnitude is about 3.5.

**Chen**

$$y = 10^x$$

$$10^3 = 1,000$$

$$10^4 = 10,000$$

$$10^{3.5} \approx 3,162$$

$$10^{3.7} \approx 5,012$$

$$10^{3.8} \approx 6,310$$

$$10^{3.74} \approx 5,500$$

The magnitude is about 3.74.

A. What is the magnitude of an earthquake with amplitude 100,000? How do you know?

B. **Construct Arguments** Critique Taylor's and Chen's work. Is each method valid? Could either method be improved? © MP.3

C. Describe how to express the exact value of the desired magnitude.

### HABITS OF MIND

**Reason** Taylor reasoned that since 5,500 was halfway between 1,000 and 10,000, that the magnitude had to be halfway between 3 and 4. What is incorrect about Taylor's reasoning? © MP.2

**EXAMPLE 1**  **Try It! Understand Logarithms**

1. Write the inverse of  $y = 8^x$ .

**EXAMPLE 2**  **Try It! Convert Between Exponential and Logarithmic Forms**

2. a. What is the logarithmic form of  $7^3 = 343$ ?

- b. What is the exponential form of  $\log_4 16 = 2$ ?

**HABITS OF MIND**

**Communicate Precisely** Write a sentence to describe what the equation  $\log_a b = c$  means. © MP.6

**EXAMPLE 3**  **Try It! Evaluate Logarithms**

3. What is the value of each logarithmic expression?

- a.  $\log_3 \left( \frac{1}{81} \right)$

- b.  $\log_7 (-7)$

- c.  $\log_5 5^9$



**EXAMPLE 4**  **Try It! Evaluate Common and Natural Logarithms**

4. What is the value of each logarithmic expression to the nearest ten-thousandth?
- a.  $\log 321$                       b.  $\ln 1,215$                       c.  $\log 0.17$

**HABITS OF MIND**

**Reason** In order for  $\log x$  or  $\ln x$  to be defined, what must be true about  $x$ ? © MP.2

**EXAMPLE 5**  **Try It! Solve Equations With Logarithms**

5. Solve each equation. Round to the nearest thousandth.
- a.  $\log(3x - 2) = 2$                       b.  $e^{x+2} = 8$

**EXAMPLE 6**  **Try It! Use Logarithms to Solve Equations**

6. What is the magnitude of an earthquake with a seismic energy of  $1.8 \times 10^{23}$  joules?

**HABITS OF MIND**

**Make Sense and Persevere** How do logarithms help you to solve an equation in which the variable is an exponent? © MP.1





## Do You UNDERSTAND?

- 1. ? ESSENTIAL QUESTION** What are logarithms and how are they evaluated?
- 2. Error Analysis** Amir said the expression  $\log_5(-25)$  simplifies to  $-2$ . Explain Amir's possible error. © MP.3
- 3. Vocabulary** Explain the difference between the common logarithm and the natural logarithm.
- 4. Make Sense and Persevere** How can logarithms help to solve an equation such as  $10^t = 656$ ? © MP.1

## Do You KNOW HOW?

Write each equation in logarithmic form.

5.  $2^{-6} = \frac{1}{64}$

6.  $e^4 \approx 54.6$

Write each equation in exponential form.

7.  $\log 200 \approx 2.301$

8.  $\ln 25 \approx 3.22$

Evaluate the expression.

9.  $\log_4 64$

10.  $\log \frac{1}{100}$

11.  $\ln e^5$

12. Solve for  $x$ .  $4e^x = 7$ .

