

What's Shakin'?



(San Francisco Earthquake 1906)



(San Francisco Earthquake 1989)

I. About the Math

In this activity students will use the Internet to collect data that models the logarithmic function.

II. Setting Up

Each group's computer should have an Internet browser installed. If not, the teacher can demonstrate the Internet portion of the lesson.

III. Teacher Notes

a) Objective

Students will be introduced to the logarithmic curve through an application. They will review the concepts of domain and range of data and of situations. Students will have the opportunity to sketch a curve after seeing it.

b) Teachable Moments

The teacher should guide the students in sketching the graph onto the worksheet by asking students to identify various points along the graph. This is a good opportunity to practice extending the scale of the graph in Graphical Analysis.

c) Connections

The teacher should note the differences and similarities between the logarithmic curve and the square root curve.

d) Classroom Management Tips

Groups may print their Graphical Analysis results for inclusion in their work or for posting in the classroom. Teachers may want to save this data on disk for further analysis.

e) Pre-requisites

Students should be familiar with Graphical Analysis.

f) Questions

Does Ground Motion Change ever become 0 or negative? Is it reasonable to think that the Magnitude Change would be negative?

g) Supplementary Comments

Magnitude

Modern seismographic systems precisely amplify and record ground motion (typically at periods of between 0.1 and 100 seconds) as a function of time. This amplification and recording as a function of time is the source of instrumental amplitude and arrival-time data on near and distant earthquakes. Although similar seismographs have existed since the 1890's, it was only in the 1930's that Charles F. Richter, a California seismologist, introduced the concept of earthquake magnitude. His original definition held only for California earthquakes occurring within 600 km of a particular type of seismograph (the Woods-Anderson torsion instrument). His basic idea was quite simple: by knowing the distance from a seismograph to an earthquake and observing the maximum signal amplitude recorded on the seismograph, an empirical quantitative ranking of the earthquake's inherent size or strength could be made. Most California earthquakes occur within the top 16 km of the crust; to a first approximation, corrections for variations in earthquake focal depth were, therefore, unnecessary.

Richter's original magnitude scale (ML) was then extended to observations of earthquakes of any distance and of focal depths ranging between 0 and 700 km. Because earthquakes excite both body waves, which travel into and through the Earth, and surface waves, which are constrained to follow the natural wave guide of the Earth's uppermost layers, two magnitude scales evolved - the mb and MS scales.

The standard body-wave magnitude formula is

$$m_b = \log_{10}(A/T) + Q(D,h) ,$$

where A is the amplitude of ground motion (in microns); T is the corresponding period (in seconds); and Q(D,h) is a correction factor that is a function of distance, D (degrees), between epicenter and station and focal depth, h (in kilometers), of the earthquake. The standard surface-wave formula is

$$M_S = \log_{10} (A/T) + 1.66 \log_{10} (D) + 3.30 .$$

There are many variations of these formulas that take into account effects of specific geographic regions, so that the final computed magnitude is reasonably consistent with Richter's original definition of ML. Negative magnitude values are permissible.

For further earthquake pictures visit the site
<http://www.ngdc.noaa.gov/seg/mainmeta.shtml>

h) Follow-ups/extensions

Students should be made aware that using the Internet to locate data tables might be useful in their project.

i) Answers

IV. TEKS

(b) Foundations for functions: knowledge and skills and performance descriptions.

(1) The student uses properties and attributes of functions and applies functions to problem situations. Following are performance descriptions.

(A) For a variety of situations, the student identifies the mathematical domains and ranges and determines reasonable domain and range values for given situations.

(B) In solving problems, the student collects data and records results, organizes the data, makes scatterplots, fits the curves to the appropriate parent function, interprets the results, and proceeds to model, predict, and make decisions and critical judgments.

(c) Algebra and geometry: knowledge and skills and performance descriptions.

(1) The student connects algebraic and geometric representations of functions. Following are performance descriptions.

(A) The student identifies and sketches graphs of parent functions, including linear ($y = x$), quadratic ($y = x^2$), square root ($y = \sqrt{x}$), inverse ($y = 1/x$), exponential ($y = a^x$), and logarithmic ($y = \log_a x$) functions.

What's Shakin'?



San Francisco Earthquake - 1906

Earthquakes vary broadly in size. If an earthquake is felt or causes perceptible surface damage, then its intensity of shaking can be subjectively estimated. However, many earthquakes occur in the ocean, in remote areas, or at great depths inside the earth. A seismograph is a scientific instrument that records and amplifies ground motion as a function of time. This data is applied to a mathematical formula that assigns the earthquake a **magnitude** (a number that indicates the intensity of the earthquake).

We can explore how much the motion of the ground changes with the change in the magnitude numbers. A table describing some of these changes can be found on the internet.

Getting the Data

- ❑ Open your Internet browser.
- ❑ In the address box of your browser type
- ❑ <http://wwwneic.cr.usgs.gov>
 - Choose "General Earthquake Information"
 - Choose "Earthquake Lists, Facts and Statistics" under Magnitude
 - Choose "Earthquake Facts and Statistics"
- ❑ Scroll down to **Table 4 - magnitude vs. Ground Motion and Energy**
- ❑ Record the data in the table below. **BE CAREFUL!!!** We are recording the Ground motion change first.

Ground Motion Change (Displacement)	Magnitude Change

- 1.) What is the independent variable? _____
- 2.) What is the dependent variable? _____
- 3.) What is the domain of this data? _____
- 4.) What is the range of this data? _____

Graphing the Data

Close your Internet browser.

Open Graphical Analysis.

Enter the values from your recorded data into the table.

Change the column titles appropriately.

Double Click on the Graph screen and turn off the connecting lines feature.

From the Analyze menu choose Automatic Curve Fit.

In the Y= box type **$A \cdot \log(x)$** and **OK**

This curve is called a logarithmic curve.

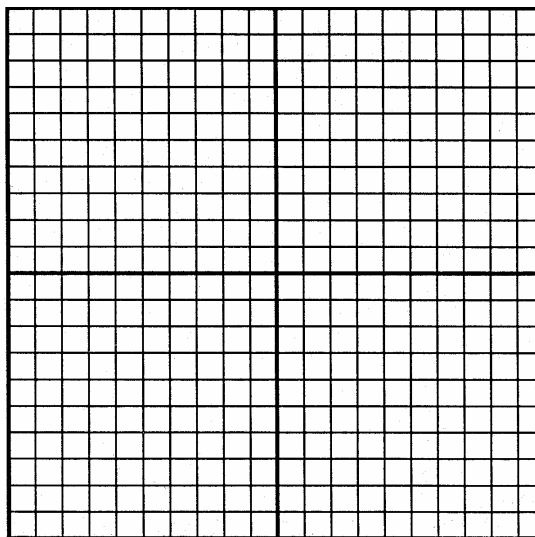
Its parent function is $y = \log(x)$.

Choose **Keep Fit**

5.) What is a reasonable **domain** for this situation? _____

6.) What is a reasonable **range** for this situation? _____

7.) Sketch the curve you saw in Graphical Analysis on the grid below.



8.) Write the equation for your curve here: _____