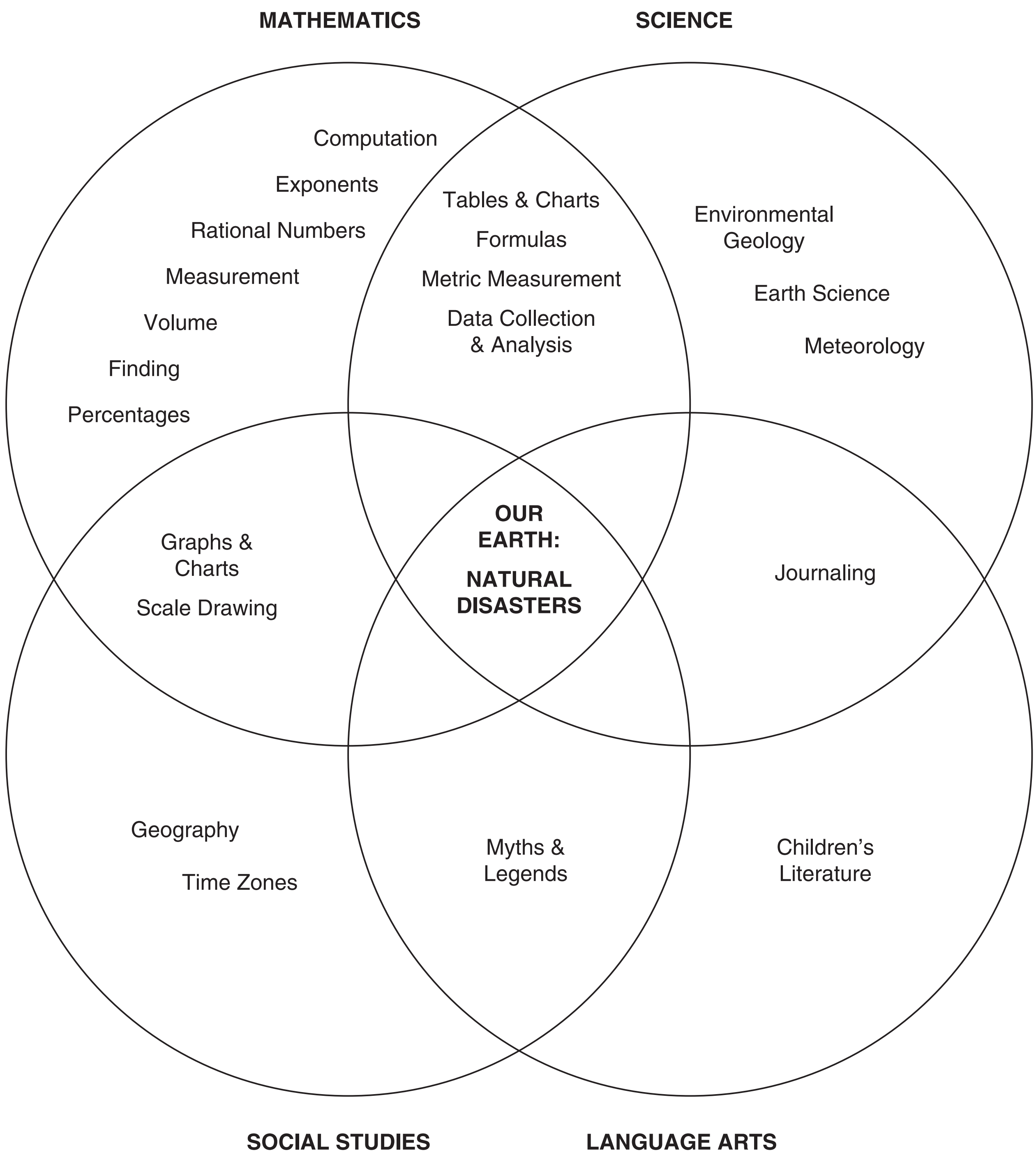
Our Earth: Natural Disasters 1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Our Earth: Natural Disasters 1

The profound study of nature is the most fertile source of mathematical discoveries.

—Joseph Fourier

INTRODUCTION

The study of natural disasters extends across the disciplines. Their enormous power is awesome. We are all fascinated with such destructive natural forces, and this topic has built-in motivation for middle school youngsters. This chapter is subdivided into four powerful forces of nature: earthquakes, volcanoes, hurricanes, and tornadoes.

The first section examines some of the major earthquakes that have occurred throughout history. The myths and legends surrounding earthquakes date back thousands of years. According to Hindu mythology, earthquakes occurred when one of the eight elephants that carried the Earth on their backs became tired. Japanese legend blamed earthquakes on a giant catfish, the Namazu, which lived beneath the mud. These tales form a fascinating collection of stories for students. Additional literature related to the myths and legends of earthquakes can be found in the "Additional Reading" section at the end of the chapter.

The second section examines volcanoes and their destructive power. There are over 600 active volcanoes on Earth. More than half of them are found in the same area where the most powerful earthquakes occur—in the so-called "Ring of Fire." The myths and legends surrounding volcanoes are even more far-reaching than those about earthquakes. Primitive tribes paid tribute to the power of volcanoes by making sacrificial offerings to them. Literature abounds with stories of the volcanoes' staggering power, and, since major active volcanoes are located on every continent, there are obvious ties to social studies.

The third set of activities related to natural disasters examines the mathematics of hurricanes. The word *hurricane* is derived from the name of the

West Indian god of storms, Huracan. These tropical storms have local names, depending on where they originate. In the Pacific, they are called typhoons; in the Atlantic, hurricanes; in the Indian Ocean, cyclones; and in Australia, willy willies. Meteorology is a significant part of the middle school science curriculum. By studying the anatomy of hurricanes and typhoons, following the development of tropical storms, and keeping a "hurricane watch," students find the study of weather a fascinating topic in their science and social studies classes. In the mathematics class, students learn to appreciate the power of tropical storms by working through mathematical activities.

And finally, what student hasn't heard of Dorothy's trip from Kansas to the Land of Oz on the winds of a tornado? Mathematics and science lessons begin in the literature class! Tornadoes are one of nature's most amazing and frightening storms. They reach down out of thunderclouds with wind speeds that range from 200 to 300 miles per hour. If a tornado touches ground, the damage to life and property can be enormous.

In some of the activities in this book, both standard U.S. and metric measurements have been included. Either may be used in the solution of the problems.

EARTHQUAKES

Teacher's Planning Information

Background Information and Procedures

Explain to students that earthquakes are caused by a sudden movement of the Earth. For hundreds of millions of years, the forces of plate tectonics have shaped the Earth. Huge plates that form the surface of the Earth move slowly over, under, and past each other. These are solid and resist the motion of neighboring plates. When one plate gives way to the motion of a neighbor, the result is a powerful release of energy—resulting in earthquake waves. Additional information about earthquakes can be found at the end of the chapter where Additional Readings and informative Internet Web sites are described.

Just how powerful is powerful? The severity of earthquakes can be expressed in several ways—in terms of magnitude or intensity. The *magnitude* of an earthquake, usually expressed by the Richter scale, is a measure of the amplitude of the seismic waves as recorded on a seismograph. We can think of this as indicating the strength or energy released by the earthquake. The *intensity* is measured by criteria that can be seen on the Modified Mercalli Intensity Scale. This is a subjective measure that describes how strong a shock was felt at a particular location and describes the level of damage. The table below shows both of these scales and their measures of magnitude or intensity.

The activity "Significant Earthquakes Around the World—2005" asks students to organize and analyze a large quantity of data on a frequency table and draw a pie graph to visually represent the data. (Up-to-date information can be obtained at http://neic.usgs.gov/neis/ for the years following 2005.) Students can check back at this Web site to get more up-to-date information.

Earthquakes give mathematics teachers a real-world application for logarithmic numbers—a seldom-used mathematical notation skill. These are actually powers of 10. For example, $10^2 = 100$; the log of 100 = 2. If students have a scientific calculator, it should contain a key that changes 10^x to logarithmic numbers and vice versa. Read and discuss the

Mathematical Connections:
Exponential notation, organizing and analyzing data, rational numbers, volume, and graphic representation

Other Curricular Connections:
Earth science, plate tectonics, social studies, journal writing

Concepts:
Students will:

- Examine significant earthquakes and make a pie graph of the data
- Compute the difference in magnitude of exponential numbers
- Subtract decimals
- Use scientific calculators to compute differences in magnitude
- Work collaboratively to problem-solve volume of a rectangular prism

Materials Needed:

- Scientific calculators (10^x or y^x key is needed)
- Copies of all earthquake student worksheets
- Protractors, rulers, and colored pencils (or markers)

example on the "Magnitude of Earthquakes" student worksheet with the students. To compute the difference in magnitude, students must find the difference between the exponents. For example, an earthquake with a magnitude of 5 could be written as 10^5. An earthquake with a magnitude of 7 could be written as 10^7. The difference is 10^2, or 100 times the magnitude. Students will need to use calculators to compute the difference in magnitude when the exponents are decimal fractions.

The next lesson asks students, "How Deep Is Deep?" Working in groups of five or six, students are asked to estimate the number of people that might fit in a hole that is 3 feet (1 m) wide and 40 feet (12 m) deep. For the purposes of this problem, it is assumed that the hole formed was, in fact, a rectangular prism. It is important that students understand that the irregular shape has been modified for the purposes of this problem.

Assessment

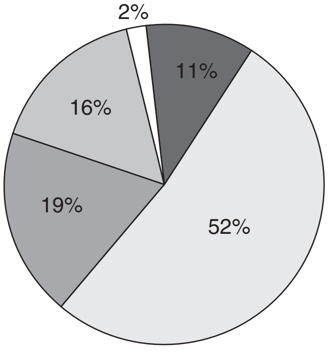
1. Student products—Accuracy of worksheets provided in the activities
2. Journal question: "Explain the difference in magnitude between an earthquake in China registering 8.5 on the Richter scale and one in California registering 6.6." [Ans.: ≈ 794 times more powerful]

Earthquakes—Selected Answers

Significant Earthquakes Around the World—2005, rounded to the nearest percent and nearest degree:

Answers to "Significant Earthquakes Around the World—2005" Activities

Magnitude	*Fraction*	*Percent*	*Degrees*
8.0–8.9	1/63	2%	7°
7.0–7.9	7/63	11%	40°
6.0–6.9	33/63	52%	187°
5.0–5.9	12/63	19%	68°
4.0–4.9	10/63	16%	58°
TOTAL	**63/63**	**100%**	**360°**



Magnitude of Earthquakes: (1) 10; (2) ≈ 3 times more powerful; (3) Many factors can affect the destructive force of earthquakes including building structures, soil, etc. A good site where students can go for hands-on experiences is http://tlc.discovery.com/convergence/quakes/interactives/makeaquake.html

How Deep Is Deep?: (1) The volume of the prism is $3 \times 3 \times 40$ or 360 ft^3; (2) The number of students is an open-ended problem with more than one possible answer.

Comparison of the Modified Mercalli Scale and the Richter Scale

Modified Mercalli Scale	*Intensity*	*Level of Damage*	*Magnitude (as a power of 10)*	*Richter Scale*
1–4	Instrumental to Moderate	No damage. Very weak.	10^0–10^3	≤ 4.3
5	Rather Strong	Damage negligible. Small, unstable objects displaced. Some dishes or glasses may be broken.	10^3	4.4–4.8
6	Strong	Damage slight. Windows, dishes, glassware broken. Furniture may be moved or overturned. Weak plaster and masonry may crack.	10^3–10^4	4.9–5.4
7	Very Strong	Damage moderate in well-built structure but considerable in poorly built structures. Furniture and weak chimneys broken. Loose bricks, tiles, plaster, and stones may fall.	10^4–10^5	5.5–6.1
8	Destructive	Damage to structures considerable, particularly if they are poorly built. Chimneys, elevated water tanks may fail. Frame houses may move and trees are damaged. Cracks appear in wet ground and steep slopes.	10^5	6.2–6.5
9	Ruinous	Structural damage severe; some buildings will collapse. Serious damage to reservoirs and underground pipes, Conspicuous cracks in ground.	10^5	6.6–6.9
10	Disastrous	Most masonry and frame structures/ foundations destroyed. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, and embankments. Sand and mud shifting on beaches and flat land.	10^6	7.0–7.3
11	Very Disastrous	Few or no masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Rails bent. Widespread landslides.	10^6–10^7	7.4–8.1
12	Catastrophic	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Great devastation and loss of life.	10^7–10^8	> 8.1

Source: Adapted from various sites including http://fema.gov

Significant Earthquakes Around the World—2005

Name ______________________________

Date ____________________ Class ____________________

It is estimated that although there are 500,000 detectable earthquakes in the world each year, only 100,000 of those can be felt, and 100 of them cause damage. Let's examine this list of 2005's significant earthquakes (from January 1 to September 9).

Date	*Magnitude*	*Date*	*Magnitude*	*Date*	*Magnitude*	*Date*	*Magnitude*
Jan. 1	6.6	Feb. 16	6.6	Apr. 11	6.7	June 15	6.5
Jan. 10	5.4	Feb. 19	6.5	Apr. 11	6.8	June 16	4.9
Jan. 10	5.4	Feb. 22	6.5	Apr. 19	5.5	June 17	6.7
Jan. 12	6.8	Feb. 26	6.8	May 1	4.5	June 20	4.7
Jan. 16	6.6	Mar. 2	7.1	May 3	4.9	July 2	6.6
Jan. 19	6.5	Mar. 2	4.9	May 5	6.5	July 5	6.7
Jan. 23	6.2	Mar. 5	5.8	May 12	6.5	July 23	6.0
Jan. 25	4.8	Mar. 9	5.0	May 14	6.8	July 24	7.3
Jan. 25	5.9	Mar. 12	5.7	May 16	6.6	July 25	5.0
Feb. 2	4.8	Mar. 14	5.8	May 19	6.9	Aug. 5	5.2
Feb. 5	6.6	Mar. 14	4.9	May 23	4.3	Aug. 13	4.8
Feb. 5	7.1	Mar. 20	6.6	June 4	6.1	Aug. 16	7.2
Feb. 8	6.8	Mar. 21	6.9	June 6	5.7	Aug. 21	5.1
Feb. 14	6.1	Mar. 28	8.7	June 13	7.8	Sept. 9	7.7
Feb. 15	6.1	Apr. 10	6.7	June 14	6.8		
Feb. 15	5.5	Apr. 10	6.5	June 15	7.2		

Source: http://neic.usgs.gov/neis/eqlists/sig_2005.html

Directions: Working with a partner, use the significant earthquake data to complete the table below. Use your analysis of the data to answer the questions that follow.

Frequency Table

Magnitude	*Tally*	*Fraction*	*Percent*	*How Many Degrees of a Circle?*
8.0–8.9				
7.0–7.9				
6.0–6.9				
5.0–5.9				
4.0–4.9				
TOTAL				

1. Do you think the data shown represent all of the earthquakes that occurred in 2005? Why or why not?

2. Based on your analysis of the data and the information provided, predict how many earthquakes greater than 7.0 will occur, on average, in any given year. Explain your reasoning.

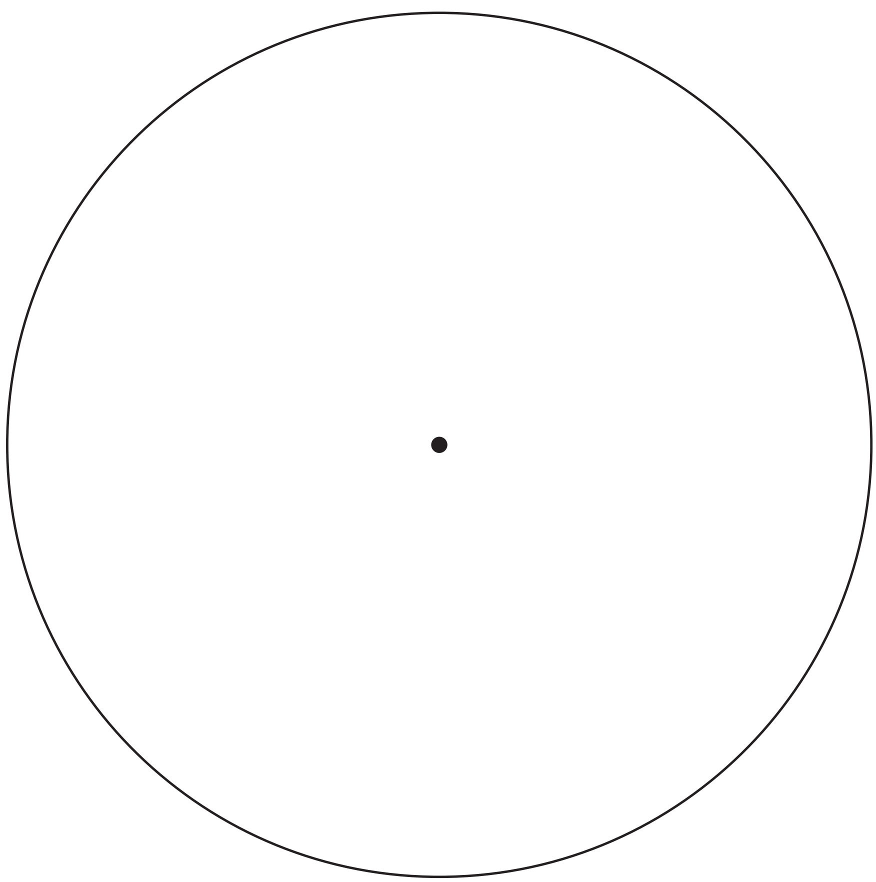
Significant Earthquakes Around the World—2005

Name ______________________________

Title of graph ______________________________

Make a circle graph that represents the data on the Frequency Table.

Circle Graph



Magnitude of Earthquakes

Name ____

Date ____________________ Class ____________________

The difference in magnitude of earthquakes can be expressed as exponents with a base of 10. For example: There are two earthquakes, one with a magnitude of 5 and the other 7; the difference is 2. This means that one of these earthquakes is 10^2, or 100 times as powerful as the other. On the table below are 10 of the most powerful earthquakes of the twentieth century. The difference between 9.5 and 9.2 is 0.3. Using a calculator, we find that $10^{0.3} = 2$. This means that an earthquake registering 9.5 is twice as powerful as one that registers 9.2. Use your calculators to answer the questions below.

Ten Most Powerful Earthquakes		
Year	*Location*	*Richter Scale*
1960	Chile	9.5
1964	Prince William Sound, Alaska	9.2
2004	Off the Coast of Northern Sumatra	9.0
1952	Kamchatka, Russia	9.0
1906	Off the Coast of Ecuador	8.8
2005	Northern Sumatra, Indonesia	8.7
1965	Rat Island, Alaska	8.6
1957	Andreanof Islands, Alaska	8.6
1950	Assam, Tibet	8.6
1963	Kuril Islands, Northern Pacific Ocean	8.5

Source: http://neic.usgs.gov

1. How much more powerful is an earthquake that registers 9.5 than one that registers 8.5?

2. How much more powerful was the earthquake off the coast of Chile than the one in Kamchatka?

3. In 1976, an earthquake in Tangshan, China, registered 7.9 on the Richter scale. The death toll has been estimated at about 250,000 people. Yet only 125 people died because of the earthquake (and resulting tsunami) in Prince William Sound, although it registered 9.2 on the Richter scale. Do some research and determine why sometimes there is greater loss of life in earthquakes with lower magnitudes.

How Deep Is Deep?

Name ______________________________

Date ____________________ Class ____________________

The 1964 earthquake that occurred in Prince William Sound, Alaska, lasted for 7 minutes. During this earthquake, the ground rolled like waves on the ocean and huge cracks opened in the ground. How deep were these cracks? Some were 3 feet wide and 40 feet deep! Many buildings fell into these deep crevices.

If the crack in the Earth were a square prism with sides of 3 feet and a depth of 40 feet, what would be the volume of this hole? How many students would fit in a hole this size? Work with your classmates to find a solution to this problem. Write your solution in the space provided.

The approximate number of students who would fit in the hole: __________

The volume of the hole: __________

How we solved these problems: