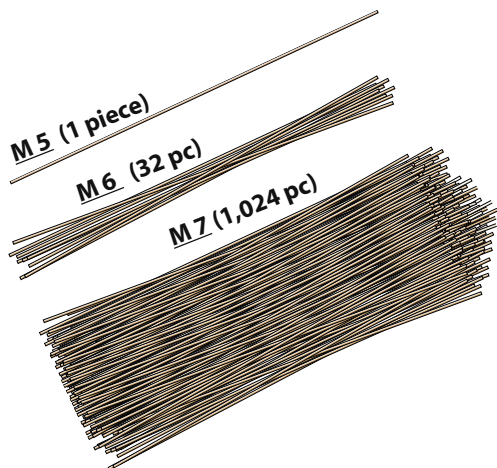


Activity—Pasta Quake

Model of Earthquake Magnitude. Demonstration & Student Worksheets

Learn about earthquake magnitude by breaking different size bundles of uncooked spaghetti noodles. Short classroom activity for grades 4 and up emphasizes the difference between magnitudes.



Background—Intensity or Magnitude?

The severity of an earthquake can be expressed in terms of both intensity and magnitude. However, the two terms are quite different, and they are often confused.

Intensity is based on the observed effects of ground shaking on people, buildings, and natural features. It varies from place to place within the disturbed region depending on the location of the observer with respect to the earthquake epicenter.

Magnitude is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of the earthquake waves recorded on instruments which have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value.



NGSS Science Standards

- From Molecules to Organisms—Structures and Processes: MS-LS1-8
- Motion and Stability—Forces and Interactions: HS-PS2-1, MS-PS2-2
- Energy: MS-PS3-1, MS-PS3-5
- Waves and Their Applications in Technologies for Information Transfer: MS-PS4-1, HS-PS4-1, MS-PS4-2, HS-PS4-5
- Earth’s Systems: HS-ESS2-1, MS-ESS2-2, HS-ESS2-2, MS-ESS2-3



VIDEO: Watch this short video demonstrations of the Pasta Quake activity:
DEMO_Pasta Quake_Butler.mov

Video

 2. Earthquakes & Tsunamis >  3. VIDEOS_Earthquake & Tsunami > DEMO PastaQuake_Butler.mov

Web links to other related magnitude activities

Interactive *Calculate-the-Magnitude* activity—Instructions (**Magnitude-WebActivity.pdf**) are in the “Pasta Quake activity **RESOURCES**” folder. The game can be played at: <http://siovizcenter.ucsd.edu/library/TLTC/TLTCmag.htm>

Another interactive site to determine magnitude is Virtual Earthquake found at:
<http://www.sciencecourseware.org/GLOL/>

Pasta Quake—The San Francisco Treat*

Demonstration to learn the concept of magnitude & log scale.

Time: 15-20 Minutes

Target Grade Level: 4th grade and up

Content Objective: Students will learn the earthquake magnitude scale by breaking different amounts of spaghetti. Visual scale of the pasta emphasizes the relative differences between magnitudes; each whole step in magnitude.

To Do and Notice

The following demonstration may also be done in small groups.

Hold up one piece of spaghetti. Bend the piece between your hands until it breaks. Notice the work it takes to break the spaghetti. Call this a **5** on the Pasta Magnitude scale (**M5**). Now ask, “What would you need to multiply this single piece of spaghetti by to equal a Pasta Magnitude **6**? (The answer is 32.)

Hold up the smallest bundle of 32 strands of spaghetti. Bend the bundle until it breaks. Notice the work it takes to break the bundle. If the pasta magnitude scale were like the earthquake magnitude scale, this would be a Pasta Magnitude **6** break. Notice that the bundle is about the diameter of a large/fat drawing pencil (1.2 cm or .47 in). What did you notice? Was it still fairly easy to break? How did the bundle break - all at once or a strand at a time? We will come back to this a little later.

We can now find out how large the next bundle of spaghetti representing a Pasta Magnitude **7** would be. We start by multiplying 32 pieces of spaghetti representing Pasta **M6** by 32 = 1,024 pieces of spaghetti representing an **M7**. We can determine the new cross sectional area by multiplying the area of the **M6** (1.135 cm²) by 32 which gives us 36.32 cm² for an **M7**. To find out how large this new bundle will be, we will calculate the diameter of the circular area. (Refer to the Pasta Quake Math page.) The new diameter of the Pasta **M7** is 6.8 cm or 2.67 in.

Hold up the small 32 strand bundle and the large bundle of 1,024 strands of spaghetti. Notice that the scale of magnitude has increased from the cross sectional area of a fat pencil = **M6**, to a tennis ball = **M7**. How much energy do you think it would take to break a bundle of spaghetti this large? You can then break the large bundle of spaghetti, or flex it without breaking to show that it takes much more effort to make the bundle break.

Holding up the large bundle of pasta, ask “What would you need to multiply this bundle by to equal a Pasta **M8**?

Materials

1# package of thin spaghetti *or*
2# package of regular spaghetti.

(The answer is 32.) We start by multiplying 1,024 pieces of spaghetti representing Pasta **M7** by 32 = 32,768 pieces of spaghetti representing an **M8**. We can determine the new cross sectional area by multiplying the area of the **M7** (36.32 cm²) by 32 which gives us 1,162.24 cm² for a **M8**. To find out how large this new bundle will be, we will calculate the diameter of the circular area. (Refer to the Pasta Quake Math page.) The new diameter of the Pasta **M8** is 38.46 cm or 15.14 in.

Hold up a circle with the new 38.46 cm or 15.14 in diameter. Notice that the scale of magnitude has increased from the cross sectional area of a fat pencil = **M6**, to a tennis ball = **M7**, to the size of a beach ball = **M8**. How much energy do you think it would take to break a bundle of pasta this large?

Now let’s consider a Pasta Magnitude **9** earthquake. How big of a spaghetti bundle do you think this will be? Look around the room for a comparable diameter and make an educated guess based on how the sizes have been progressing. Let’s do the math. Once again, we start by multiplying 32,768 pieces of spaghetti representing Pasta **M8** by 32 = 1,048,576 pieces of spaghetti representing an **M9**. We can determine the new cross sectional area by multiplying the area of the **M8** (1,162.24 cm²) by 32 which gives us 37,191.68 cm² for the **M9**. To find out how large this new bundle will be, we will calculate the diameter of the circular area. (Refer to the Pasta Quake Math page.) The new diameter of the Pasta **M9** is 217.62 cm or 85.38 in, which is also 7’ .14”!

Hold up a circle of plastic tarp with this new diameter. Notice that we have changed from the cross section diameter of a fat drawing pencil = **M6**, to a tennis ball = **M7**, to the size of a beach ball = **M8** and now to a circle with the diameter slightly larger than the height of a door. How much energy do you think it would take to break a bundle of spaghetti this large? Now we can begin to understand the energy involved in a great Cascadia Subduction Zone earthquake

Pasta Quake Math

The following math shows the calculations used to determine the size of each bundle of spaghetti for magnitudes 6, 7, 8 and 9 to go with the Pasta Quake Magnitude activity. Magnitude increases by a factor of 32.

To calculate increasing magnitudes, we will work with the cross section area of bundles of spaghetti.

To increase the magnitude, the cross section area in cm^2 is multiplied by 32. We will also find the diameter of the bundle to see how the size of the bundles of spaghetti increases with each magnitude.

Magnitude	Strands of Spaghetti	Area of the bundle	Diameter of the bundle
5	1		
6	32	1.135 cm^2	1.2 cm or 0.47 in
7	1,024	36.32 cm^2	6.8 cm or 2.67 in
8	32,768	1,162.24 cm^2	38.46 cm or 15.14 in
9	1,048,576	37,191.68 cm^2	217.62 cm or 85.68 in or 7' 14"

Working the math:

Magnitude 6:

A 32 strand bundle of spaghetti = an area of 1.14 cm^2 .
 To determine the diameter of the bundle, divide the area by π (3.14159) = .36 cm^2 .
 Next, take the square root of the product to determine the radius $\sqrt{.36 \text{ cm}^2} = .6 \text{ cm}$.
 And finally multiply by 2 to determine the new diameter .6 cm x 2 = 1.2 cm or 2.67 in.

To increase a **M6** to **M7**, multiply the area of **M6** 1.14 cm^2 by 32 = 36.32 cm^2

Magnitude 7:

A 1,024 strand bundle of spaghetti = an area of 36.32 cm^2 .
 To determine the diameter of the new bundle, divide the area by π (3.14159) = 11.56 cm^2
 Next, take the square root of the product to determine the radius $\sqrt{11.56 \text{ cm}^2} = 3.4 \text{ cm}$.
 And finally multiply by 2 to determine the new diameter 3.4 cm x 2 = 6.8 cm or 2.67 in.

To increase a **M7** to **M8**, multiply the area of **M7** 36.32 cm^2 by 32 = 1,162.24 cm^2

Magnitude 8:

A 32,768 strand bundle of spaghetti = an area of 1,162.24 cm^2 .
 To determine the diameter of the new bundle, divide the area by π (3.14159) = 369.95 cm^2 .
 Next, take the square root of the product to determine the radius $\sqrt{369.95 \text{ cm}^2} = 19.23 \text{ cm}$.
 And finally multiply by 2 to determine the new diameter 19.23 cm x 2 = 38.46 cm or 15.14 in.

To increase a **M8** to **M9**, multiply the area of **M8** 1,162.24 cm^2 by 32 = 37,191.68 cm^2

Magnitude 9:

A 1,048,576 strand bundle of spaghetti = an area of 37,191.68 cm^2 .
 To determine the diameter of the new bundle, divide the area by π (3.14159) = 11,838.49 cm^2 .
 Next, take the square root of the product to determine the radius $\sqrt{11,838.49 \text{ cm}^2} = 108.81 \text{ cm}$.
 And finally multiply by 2 to determine the new diameter 108.81 cm x 2 = 217.62 cm or 85.68 in which also equals 7.14 feet.

Name: _____ Per: _____

Today's Date: _____

Due Date: _____



Pasta Quake!

There are 3 main ways to measure the magnitude of an earthquake. The **magnitude** is a measurement of earthquake strength based on seismic waves and movement along faults.

First, let's review. What are the 3 types of seismic waves? For each, give a brief description.

1. _____
2. _____
3. _____

What about exactly where earthquakes happen? Draw a diagram in the space below to show the difference between the **epicenter** and the **focus**.

Now, match up the 3 main scales to measure earthquakes with their descriptions:

4. Richter Scale

Measures the intensity of an earthquake. This is a measure of the strength of ground motion and has a scale of 1 - 12, but in Roman numerals, it's I - XII. One earthquake may have different ratings depending on the damage at different locations.

5. Moment Magnitude Scale

Measures the size of the seismic waves as shown on a seismograph. Good for small or close-by earthquakes.

6. Modified Mercalli Scale

Measures the total energy released by an earthquake and can be used for all sizes, near or far. This is usually what is used today.

On the Moment Magnitude Scale, each different number is a measure of the total energy released by an earthquake, and it's about 32 times greater between numbers of the scale. We can demonstrate with spaghetti:

Pasta Magnitude Scale	# of spaghetti pieces broken
3	<i>1/30</i>
4	<i>1</i>
5	<i>32</i>
6	<i>1,024</i>
7	<i>32,768</i>
8	<i>1,048,576</i>

Below is a list of some major earthquakes and their Moment Magnitude ratings:

1811-12	New Madrid (Midwestern US)	7.7
1906	San Francisco, California	7.8
1960	Arauco, Chile	9.5
1964	Anchorage, Alaska	9.2
1971	San Fernando, California	6.6
1985	Mexico City, Mexico	8.1
1989	San Francisco, California	6.9
1995	Kobe, Japan	6.9

7. Which earthquake released about 32 times more energy than the Mexico City quake of 1985?
8. Two of the earthquakes released just a little more than 32 times more energy than the 1971 San Fernando quake. They were...
9. The 1964 quake in Alaska released about 32 times more energy than the 1985 Mexico City quake and it released more than 1024 times the energy of which quake?

TEACHER ANSWER KEY—PAGE 1/2

MEASURING EARTHQUAKES



Name: _____ Class _____

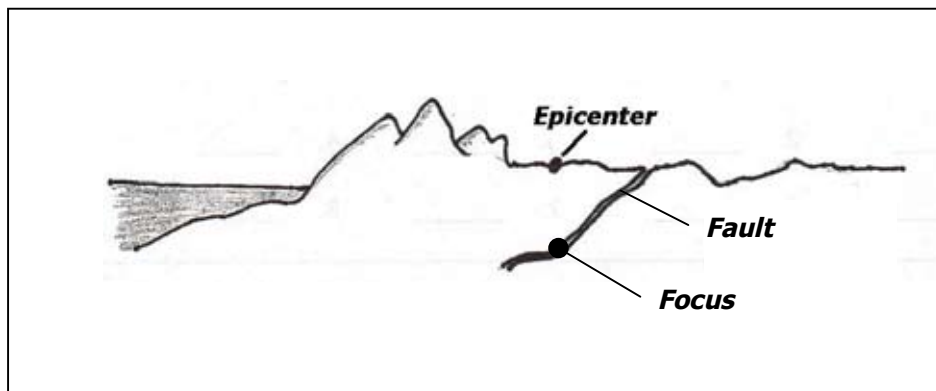
Today's Date: _____ Due Date: _____

There are 3 main ways to measure the magnitude of an earthquake. The **magnitude** is a measurement of earthquake strength based on seismic waves and movement along faults.

First, let's review. What are the 3 types of seismic waves? For each, give a brief description.

1. *P-Waves - primary waves - fastest, move straight through solids and liquids*
2. *S-Waves - secondary/shear waves - second fastest, cannot move through liquids*
3. *L-Waves - surface waves - slowest, travels along surface only*

What about exactly where earthquakes happen? Draw a diagram in the space below to show the difference between the **epicenter** and the **focus**.



Now, match up the 3 main scales to measure earthquakes with their descriptions:

- | | |
|----------------------------|---|
| 4. Richter Scale | Measures the intensity of an earthquake. This is a measure of the strength of ground motion and has a scale of 1 - 12, but in Roman numerals, it's I - XII. One earthquake may have different ratings depending on the damage at different locations. |
| 5. Moment Magnitude Scale | Measures the size of the seismic waves as shown on a seismograph. Good for small or close-by earthquakes. |
| 6. Modified Mercalli Scale | Measures the total energy released by an earthquake and can be used for all sizes, near or far. This is usually what is used today. |

ANSWER KEY—PAGE 2/2

On the Moment Magnitude Scale, each different number is a measure of the total energy released by an earthquake, and it's about 32 times greater between numbers of the scale. We can demonstrate with spaghetti:

Pasta Magnitude Scale	# of spaghetti pieces broken
3	1/30
4	1
5	32
6	1,024
7	32,768
8	1,048,576

Below is a list of some major earthquakes and their Moment Magnitude ratings:

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7. Which earthquake released about 32 times more energy than the Mexico City quake of 1985?

1964 Anchorage, Alaska

8. Two of the earthquakes released just a little more than 32 times more energy than the 1971 San Fernando quake. They were...

1811-12 New Madrid and 1906 San Francisco

9. The 1964 quake in Alaska released about 32 times more energy than the 1985 Mexico City quake and it released more than 1024 times the energy of which quake?

1989 San Francisco or 1995 Kobe