Name: _____

# Understanding Earthquakes through Analyzing and Plotting Data

You are a seismologist in Arizona. Today at 11:12 AM, the seismographs in your station just showed that an earthquake has just occurred. As a seismologist, all seismographs in Arizona are connected to your computer. Seismogram data is just starting to show up. Your job is to locate the epicenter of the earthquake and let the world (your class) know the location, magnitude and depth via a press conference.

**1. Describe what a seismologist does.**

**2. Describe the function of a seismograph.**

**3. Describe a seismogram.**

**4. What is an epicenter?**

Your boss wants the collected data in the form of a spreadsheet so that he can have an electronic copy. Create a spreadsheet that contains columns called: Station Code, Arrival of a P-Wave, Arrival of the S-Wave, and Distance from the Station. Create a row for each station. You can find the station code at the top right hand corner of each seismogram. The code will be 3 or 4 letters long.

**5. Describe a P-Wave.**

**6. Describe an S-Wave**

Distances from the epicenter are given in km (Kilometers). To calculate the distance from the epicenter you take the S-Wave time in seconds and subtract the P-Wave time in seconds and then multiply the answer by 8. The 8 is multiplied because P-Waves travel on average 1 km in 8 seconds.

Use the data from each seismogram to fill out your spreadsheet. You read seismograms from left to right. The P-Wave is recorded at the time interval where amplitude is first recorded. The S-Wave is recorded with the second set of amplitude recordings.

**7. Define amplitude.**

**8. Create a spreadsheet calculation in the "Distance" column that will automatically compute the distance from the epicenter for you. Use the copy tool to copy that formula to the other cells in the column.**

Now use a compass and the map's scale to draw a circle based on distance around each seismograph station. This is called triangulation. Where three or more circles intersect at a single point is the location of the earthquake's epicenter. If three points don't quite meet up, place a dot equidistant from each circle in the area in which they are closely lined up.

**9. What are the coordinates of the epicenter? What landmark or city is nearby? Use your coordinates in Google Earth to locate it.**

**10. Define Magnitude.**

Use the Magnitude Calculation Chart to discover the magnitude of the earthquake. For each station, place a point for the distance and a point for the greatest amplitude height. Draw a straight line to the points. Now take the average of all of your magnitudes. This is the magnitude of the earthquake.

**11. What was the magnitude of the earthquake?**

**12. Explain why you got a different magnitude for each seismograph location.**

Scientists use a scale developed by Charles Richter in 1935 to assign a value of power to an earthquake. They have since modified the scale to the Moment Magnitude Scale which measures the movement and energy of the crust. There are 10 numbers on the scale. Jumping from one number to another is 10 times more powerful. So jumping from a 3.0 to a 4.0 means that a 4.0 is 10 times more powerful than a 3.0 and a 5.0 is 100 times more powerful than a 3.0.

**13. How many times more magnitude would a 5.0 be compared to a 1.0?**

If you noticed, for each number on the scale you are adding a 0 to the amount of power. To quickly find out how much the difference of power would be, all you need to do is find the whole number difference between a 5 and a 1 and that is how many 0s you add. In this case four 0s. Another way of looking at this is a 1.0 on the richter scale is equal to $10^0$. A 2.0 is equal to $10^1$ and a 3.0 is equal to $10^{2.}$

**14. How many times more magnitude of a 10.0 earthquake be compared to a 1.0?**

Not all earthquakes are give a whole number magnitude. For example you could have a 5.8 magnitude. In order to tell what power the difference between a 5.8 and a 7.0 you find the difference. In this case the difference is 1.2. This number now becomes the power/exponent and can be written $10^{1.2}$. Now using a calculator you can find out how many times more powerful a 7.0 is compared to a 5.8. Just use your calculator and punch in 10 hit your carrot key or the $y^x$ key and 1.2. Hit equals sign. You will see the answer is 16. In other words a 7.0 is 16 times more powerful than a 5.8.

**15. Compare the the following two magnitudes: a 9.0 to a 5.2?**

**16. Compare the following two magnitudes: a 10.0 to a 3.5?**

The increased power on the Richter Scale is exponential.

**17. Why would graphing this scale using exponential numbers not be efficient or difficult? Try graphing it on a scratch paper to help you understand this.**

**18. Go to http://alabamaquake.com/energy.html#/ to find out how much energy is released from a 10.0 magnitude earthquake in terms of sticks of dynamite. How many sticks of dynamite are equal to a 10.0?**

Play with the earthquake magnitudes on the site trying different values.

In 2011 Japan had a magnitude 9.0 earthquake that was so powerful it picked up the bottom of the ocean and displaced millions of tons of water causing a deadly tsunami. The island was tilted so that parts of the island are now higher in elevation and parts of the island that were above water are now below water. In fact, in certain areas the tides flood through some towns every 12 hours. Also the island is now 13 feet wider than it was. This earthquake was so powerful that it caused the rotation/day of the earth to move quicker. Our days are now 1 millionth of a second shorter. Some parts of the island moved up to 17 feet.

Normally aftershocks follow earthquakes. In fact, you can expect an aftershock of 1 magnitude lower than than the original earthquake. There were 82 aftershocks.

**19. What would be the greatest potential magnitudes of aftershocks after the 2011 earthquake?**

Let's find out whether or not we as inhabitants of the Earth need to worry about this millionth of a second shorter day.

**20. How many millionths of a second would equal 1 day?**

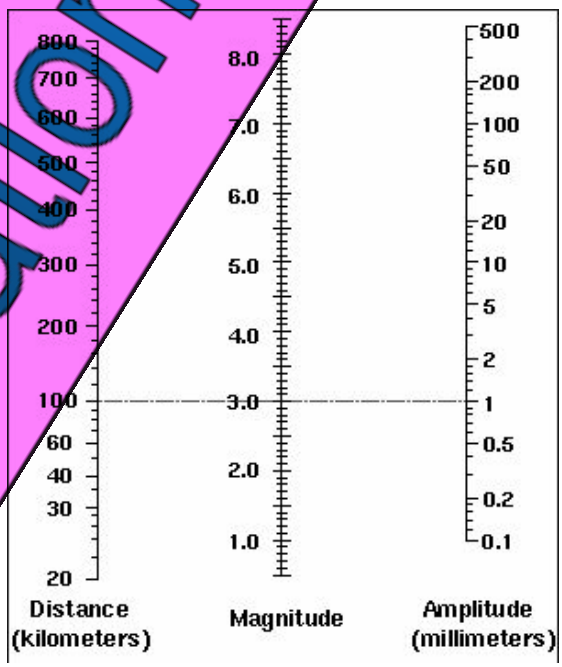
**21. How many years would it take for us to lose a day due to this speed up in the Earth's Rotation?**

**22. Is the millionth of a second worth worrying about? Explain.**

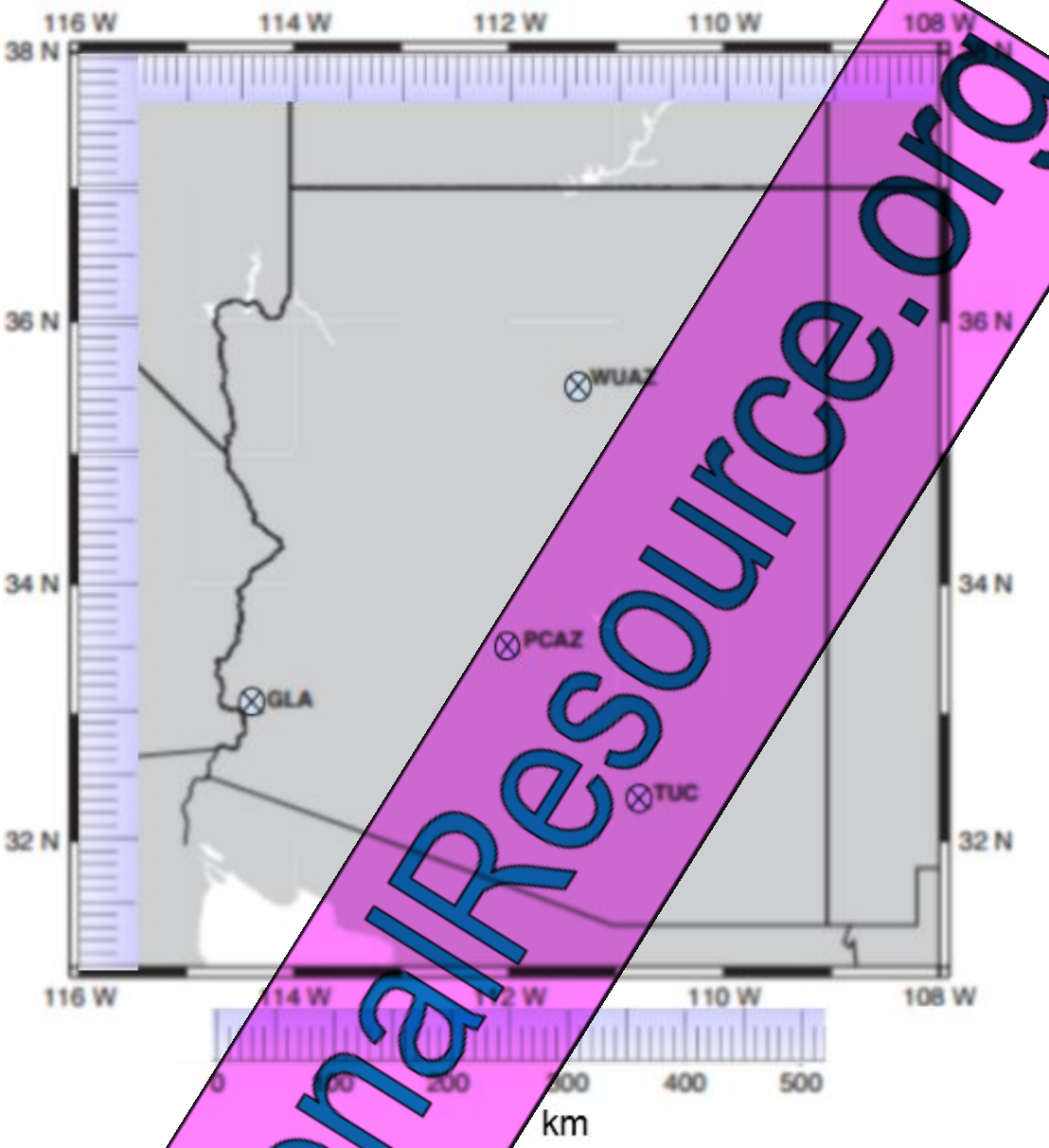
**23. Create a press release for which you will present to the class. (Worth 25 points.)**

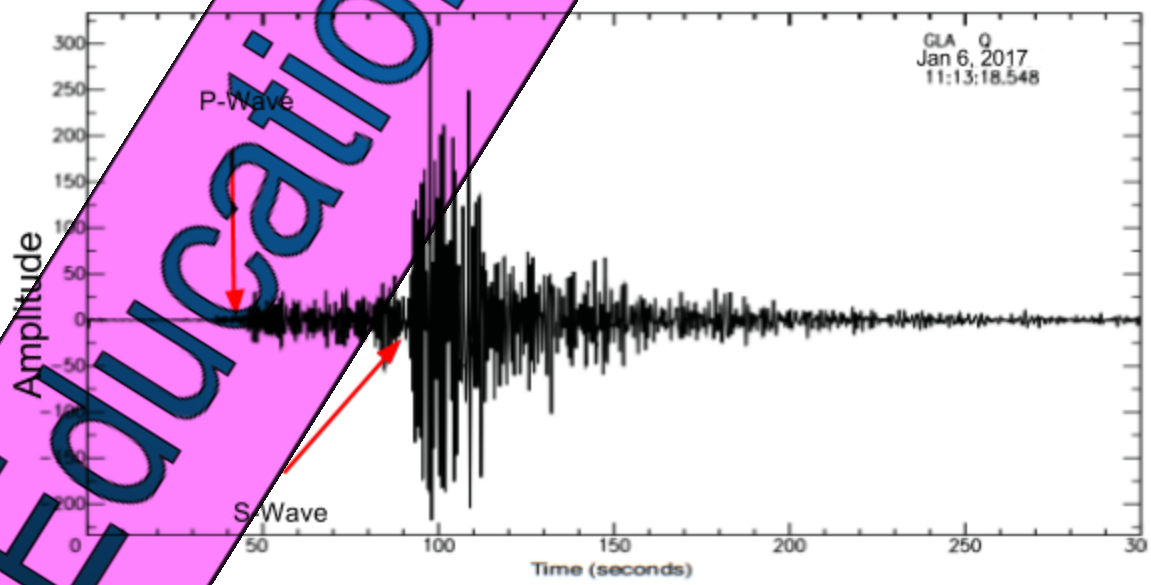
- **Items to be included**
  - **Contact info, time, date, and location**
  - **Title**
  - **Answer who, what, when, where**
  - **Give sufficient information about the facts of the event.**
  - **Check your grammar and spelling**
  - **Create it in a Google Doc. Share it with your teacher.**

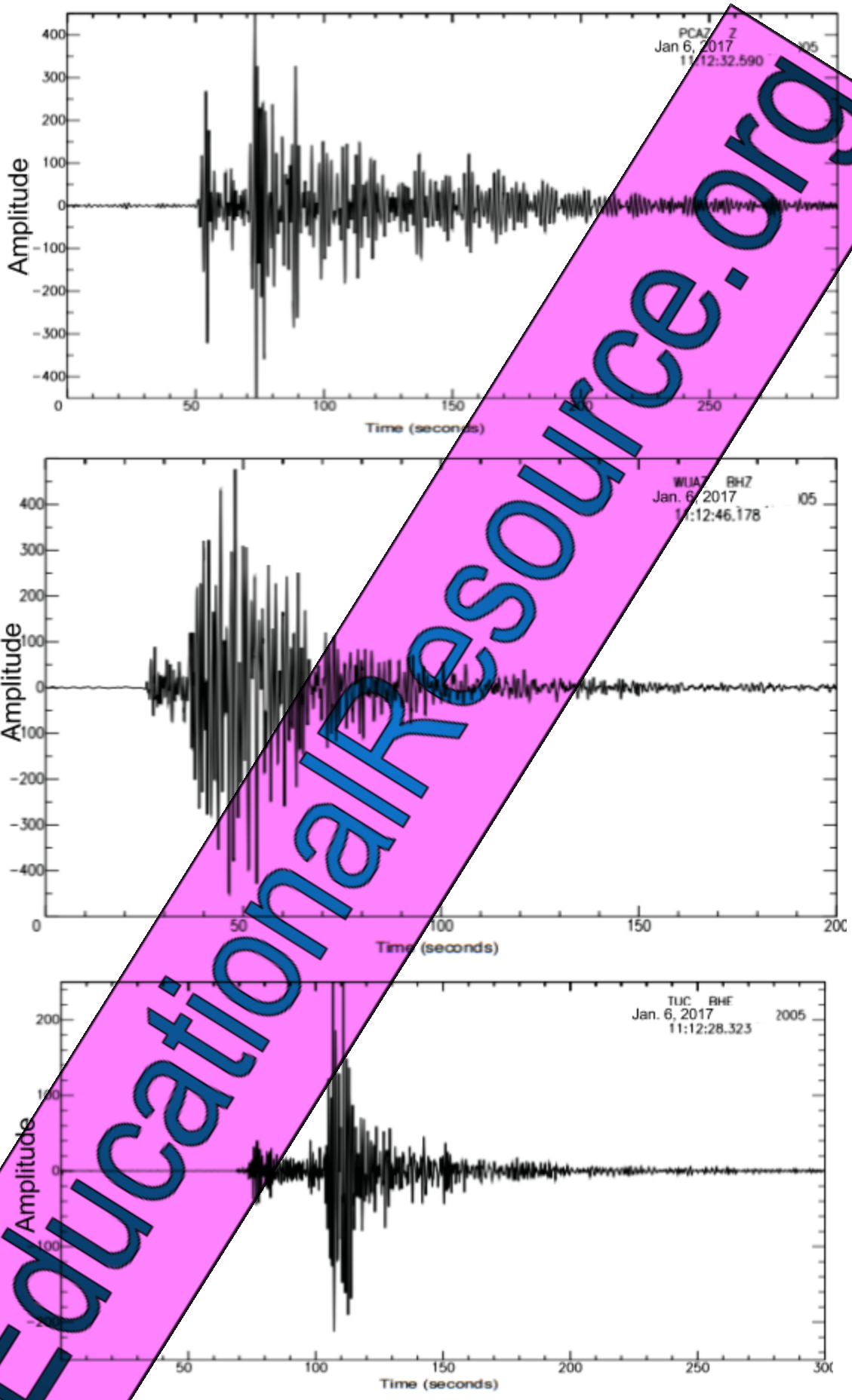
Magnitude Calculation Charts



## Earthquake Epicenter Triangulation Map





# Answer Sheet

1. De
   - [redacted]

2. Describe th
   - [redacted]

3. Describe a seismogram.
   - [redacted]

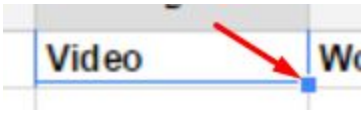
4. What is an epicenter?
   - [redacted]

5. Describe a P-Wave.
   - [redacted]

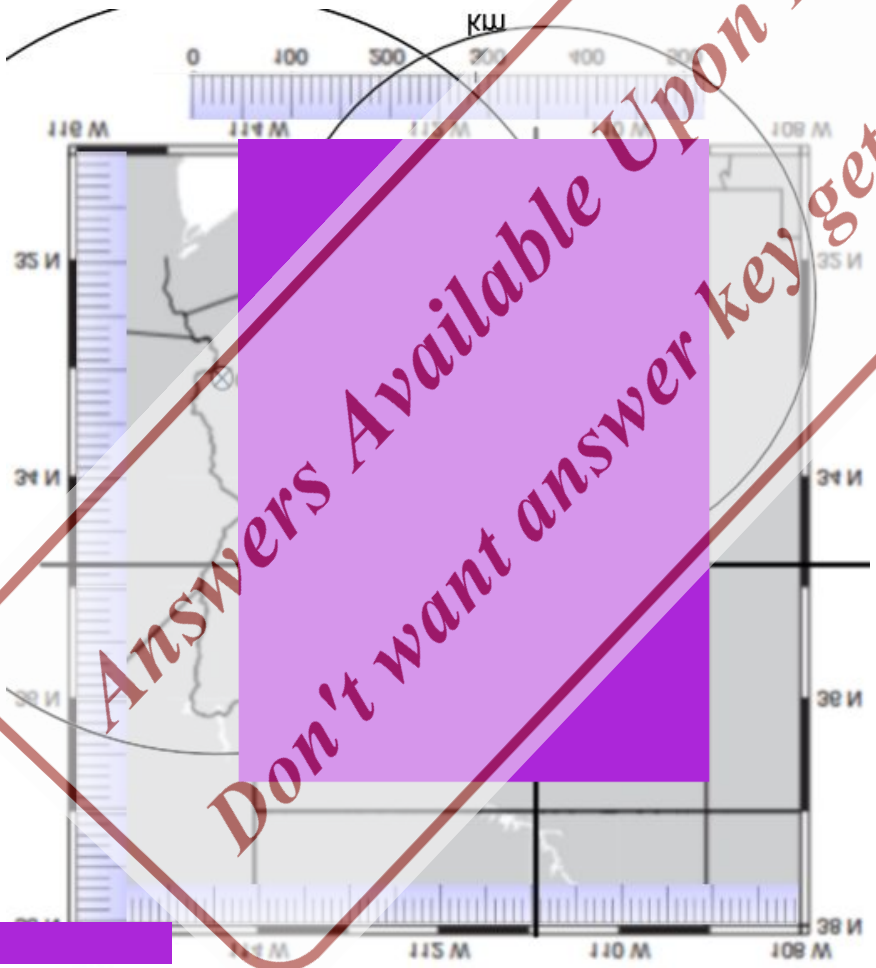
6. Describe an S-Wave
   - [redacted]

7. Define amplitude.
   - [redacted]

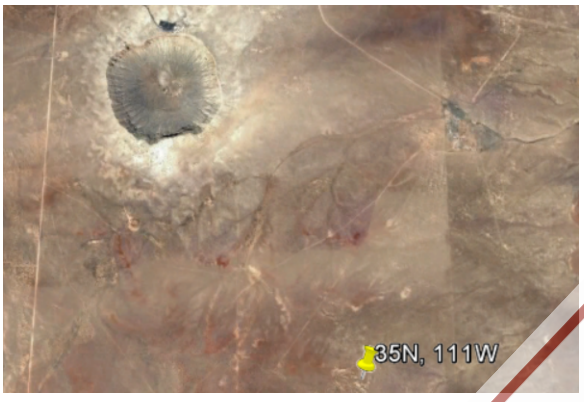
8. Create a spreadsheet calculation in the "Distance" column that will automatically compute the distance from the epicenter for you. Use the copy tool to copy that formula to the other cells in the column.
   - [redacted]

- The copy tool allows you to copy contents in specific cells of a spreadsheet. Just click on the cell or formula you want to copy and hover your mouse over the blue square until you mouse icon turns into a plus sign. Left click and hold and then drag it down.
- 


**9. What are the coordinates of the epicenter? What landmark or city is nearby?**

- [redacted]
  - If they don't round up to those degrees above and put something like [redacted] which some students do, it will take them a little further south and east.
  - Using a Smart Notebook Compus mine came out looking like this.
  - 

- [redacted]
  - I accept many areas that kids come up with, but if they did everything perfectly, they should be fairly close to [redacted]
  - 
  - Once they type in their coordinates, they may need to zoom out a bit in order to see land locations nearby. If they estimate 35N and 111W they get about 2 miles/3km southeast o [redacted] [redacted] If they try to be more precise, students will get about 18 miles or so southwest of [redacted]





**10. Define Magnitude.**

- [redacted]

**11. What was the magnitude of the earthquake.**

- [redacted]

**12. Explain why you got a different magnitude for each seismograph location.**

- [redacted]

**13. How many times more magnitude would a 5.0 be compared to a 1.0?**

- [redacted]

**14. How many times more magnitude of a 10.0 earthquake be compared to a 1.0?**

- [redacted] greater in size

**15. Compare the following two magnitudes: a 9.0 to a 5.2?**

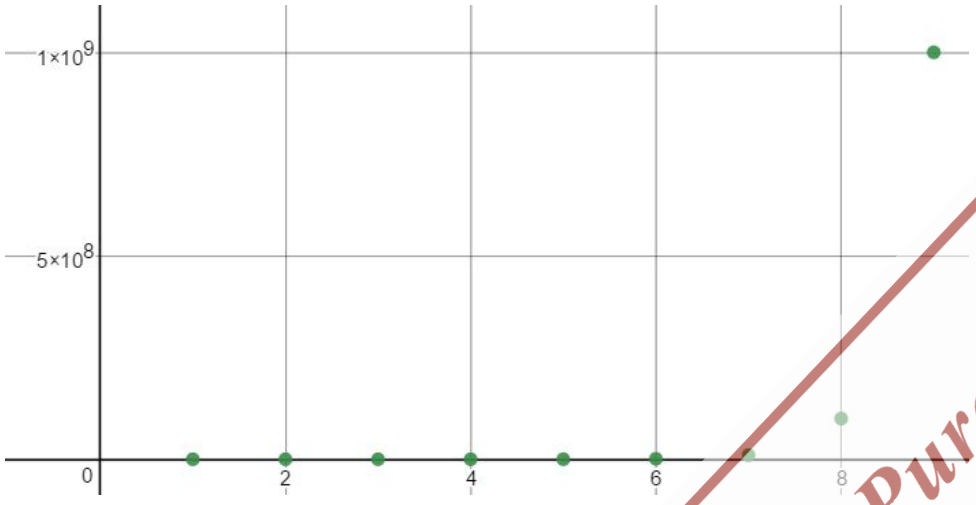
- [redacted]

**16. Compare the following two magnitudes: a 10.0 to a 3.5?**

- [redacted] million

**17. Why would graphing this scale using exponential numbers not be efficient or difficult? Try graphing it to help you understand this.**

- [redacted]
- This is also a good way to review or introduce what exponential graphs look like.




**18. Go to http://alabamaquake.com/energy.html#/ to find the answer. How many sticks of dynamite would A 10.0 BE EQUAL TO?**

- [redacted]
- When I discuss this as a class I start by making the magnitude a 1.0 which equals 1 stick of dynamite. I then have my class guess how many sticks of dynamite would a 2.0 be. Some guesses would be 2. Some guesses would be 10. They guess 10 because we talked about magnitude above and how it raises by 10 exponentially. This is where I discuss that in this case we aren't talking about how big the earthquake was, but how much energy is released instead. Energy released by an earthquake is about 30 to 32 times for each magnitude the earthquake is.
- I also talk about how much a trillion is. Their concept is not well established, just like our government. When talking about a 10.0, I have them guess how many sticks of dynamite less would be a 9.5. They should be amazed that the answer is only 5 trillion sticks. 5 trillion to 30 trillion is a huge difference. This is why some say that the world could not handle a 10.0.

**19. How big would you have expected the aftershock to be after the 2011 earthquake?**

- [redacted] 9.0 was the original.

**20. How many millionths of a second would equal 1 day?**

- It would take [redacted] to shave off [redacted] It would take [redacted] days to shave off 1 minute. It would take [redacted] days to shave off 1 hour. It would take [redacted] days to shave off 1 day.

**21. H[redacted]ny years would it take for us to [redacted]ay due to this speed up in the Earth's Rotation?**

- [redacted] billion days divided by 365 equals [redacted] illion years.

**22. Is the millionth of a second worth worrying about?**

- [redacted]

**23. Create a press release for which you will present to the class.**

- This is where I let the students be a little creative. As long as they include the information asked for. I don't require a specific length. It just needs to be written well.