**Activity 5.3.2 Earthquakes!**

In 1935, Charles Richter (<http://en.wikipedia.org/wiki/Charles_Francis_Richter>) and Beno Gutenberg created the Richter scale to measure the magnitude of earthquakes . The formula is based on the largest wave recorded on one particular kind of seismometer that was located 100 kilometers from the epicenter of that quake in California. Scientists quantify the size of an earth quake by magnitude and intensity. Magnitude is a measure of the amount of energy released at the source of an earthquake. It is a quantitative measure of the actual size of the earthquake. It is determined by the logarithm of the amplitudes of waves recorded by seismographs. Adjustments must be made for the distances between the various seismographs and the center of the earthquake. A seismometer, sort of like a sensitive pendulum, records the shaking of the earth. Intensity of an earthquake measures the actual shaking produced by the earthquake at a given location. So an earthquake has just one magnitude but the intensity will differ from location to location. It is determined by the effects of the earthquake on people, buildings, the natural environment. It may be recorded by the Modified Mercalli Intensity Scale. At the end of this activity a bit of that scale can be found. A simplified version of the Richter model is , where *M* is the magnitude on the Richter scale of the earthquake, *A* is the amplitude of earthquake measured by the amplitude of the wave on the seismograph at the fixed location but today adjusted with readings from other seismographs, and is the “reference” amplitude of the smallest earth movement that can be recorded by a seismograph. Amplitude measurements are given in multiples of .

For each increase of 1 on the Richter scale, meaning an increase of 1 unit of magnitude, there be 10 times the amplitude on the seismograph. To see this, consider an earthquake that measures 5 on the Richter scale. The amplitude of the measured earthquake is , since 5 = log(). Also, = indicating a factor of 10 times the amplitude of an earthquake that measures 4 on the Richter scale. The Richter scale is still used for smaller earthquakes but for larger ones the moment magnitude scale is now commonly used.

1. On December 26, 2004, the Indian Ocean earthquake had an amplitude of 1,999,262,315 A0. What was the magnitude of this earthquake?

M = log(1,999,262,315 A0/ A0)

SO M = log(1,999,262,315)= **9.3**

1. The 1906 San Francisco earthquake is estimated to be 7.8 on the Richter scale. How many times bigger was the Indian Ocean earthquake than the San Francisco earthquake?

The difference in the two Richter scale measurements is , **therefore the Indian Ocean earthquake is or almost 32 times bigger than the San Francisco earthquake.**

Now the magnitude scale is really comparing the amplitudes of the waves on a seismogram (you will study waves and amplitudes in the next unit) but not the strength (energy) of the earthquakes. So for example, although the Indian Ocean earthquake is 32 times bigger than the San Francisco earthquake as measured on the seismograms, how much stronger was it. It is the strength or energy that knocks down structures and does the other damage. To determine this we need another formula that says **the log E is proportional to 1.5 M** where E is energy and M is magnitude. So therefore **E is proportional to 101.5M** and 10(1.5(1.5)) so the Indian Ocean earthquake was about 178 times stronger.

Now you try.

1. What is the magnitude of an earthquake that has a measured intensity of 57,000 A0?
2. What is the amplitude of an earthquake that has a magnitude of 6.3 on the Richter scale?
3. If one earthquake’s amplitude is 10 times that of another earthquake, how much larger is its magnitude on the Richter scale?
4. If an earthquake has a magnitude of 2.6 on the Richter scale, what is the magnitude on the Richter scale of an earthquake that has an amplitude 15 times greater?
5. In April, 2015, Nepal was devastated by an earthquake that measured 7.9 on the Richter scale. In May of the same year, another earthquake measuring 7.3 hit the region. How much larger was the April earthquake compared to the one the following month?

6. How much stronger was the bigger earthquake?

1. The location and Intensity of some big earthquakes are listed below. Today these large quakes would be measured using the Moment Magnitude Scale. What was their magnitude on the Richter Scale?
2. Iran 2003, 106.6I0
3. China 2008, 107.9I0
4. Peru 2007, 108.0I0
5. Find the Richter Scale ratings for earth quakes having the following amplitudes or intensity
6. 10000 I0
7. 1000000 I0
8. 1500 I0

Brief part of the Modified Mercalli Intensity Scale

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| Magnitude | Intensity |
| 1.0 – 3.0 | I Not felt except maybe by a very few individuals under the best of circumstances |
| 3.0 – 3.9 | II - III Felt perhaps by a few in upper floors of buildings if they are at rest to noticeable indoor especially if upstairs of buildings. May feel like a truck went by outside your building. Most do not recognize it is an earthquake. |
| 5.0 -5.9 | VI – VII Many frightened. Moving of heavy furniture. Some plaster falls from the ceiling to some damage to chimneys and poorly constructed dwellings. Damage slight to well-constructed buildings. |
| 6.0 – 6.9 | VII – IX Damage slight to specially designed buildings but ordinary buildings may partially collapse. Monuments, chimneys walls fall to buildings shifted off their foundations and even specially designed buildings will have considerable damage. |
| 7 or greater | X – XII Most structures and their foundations destroyed to bridges destroyed to total destruction. |