**FDSCI 201 Guided Lab 2: Earthquakes Around the World (15 points)**

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Class section \_\_\_\_\_\_\_\_\_ Time Spent: \_\_\_\_\_\_

**Outcomes:**

* Determine where recent earthquakes occur and identify their plate tectonic setting.
* Do an initial seismic risk evaluation based on fault maps.
* Identify the plate tectonic settings that are most at risk from very large earthquakes and tsunamis.
* Compare energy output from various earthquakes.

***Instructions:***

* *You’ll need the ‘FDSCI201.kmz’ file from I-Learn.*
* *Double click the saved file to open it in Google Earth, or open from Google Earth (File… open).*

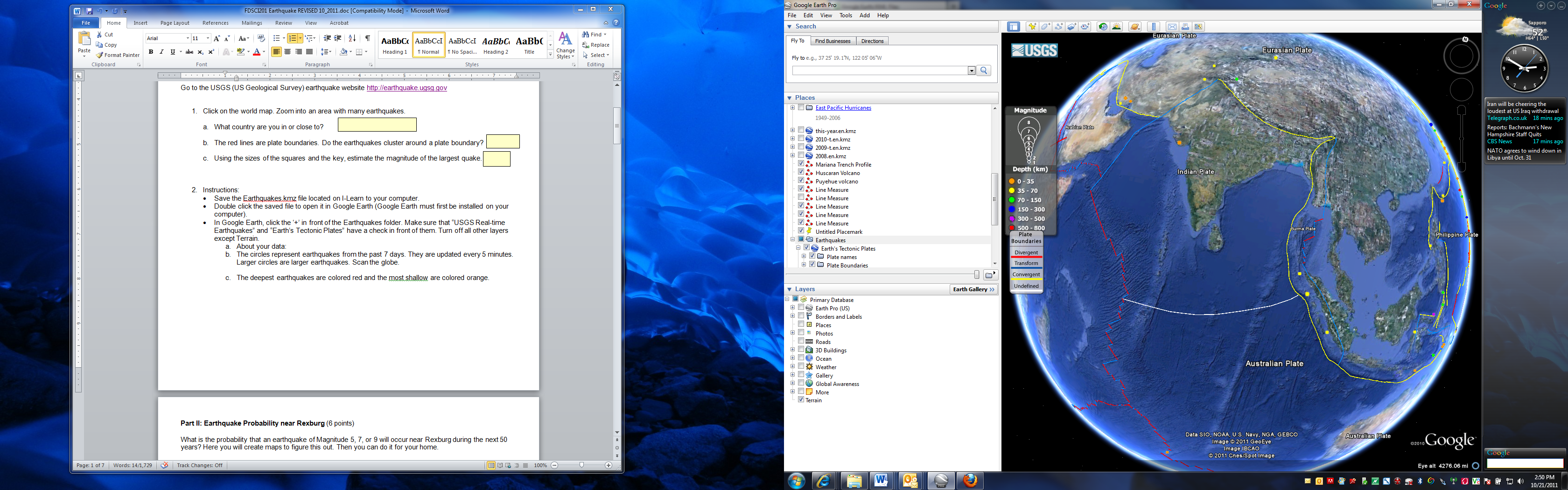
**Part I: Discover Earthquake Location and Magnitude**

In Google Earth:

* Expand (click the ‘+’) Guided Lab 2 folder.
* Toggle on “USGS Real-time Earthquakes” and “Earth’s Tectonic Plates.”
* Turn off all other layers except Terrain.

About the data:

* Circles represent earthquakes from the past 7 days. They are updated every 5 minutes.
* Larger circles represent larger magnitudes.
* You can click any quake to learn more about it. (You will need to zoom in to see most of the earthquakes).
* Earthquakes are colored by depth according to the scale below (Figure 1)

 Figure 1. Depth scale for Earthquakes

**Part II: Discover Faults and Quakes -- Field Trip**

**Bay Fault Map**

In Google Earth:

- Toggle on “Bay Fault Map” and “Labels” (located under Layers > Borders and Labels”).

- Toggle off “USGS Real-time earthquakes.”

- Double click on “Bay Fault Map.”

All of those red, orange, and yellow lines are the traces of active faults. The San Andreas Fault gets all the attention, but look at the other significant faults in the San Francisco Bay Area. Put the cursor on a fault to discover its name (fault name will be highlighted in the Places menu).

**1. Zoom in and examine the locations of faults relative to cities housing, businesses, freeways, and development in general. How would you describe the level of seismic hazard in the Bay Area?**

A. low B. moderate but localized C. moderate and widespread D. high and widespread

**2. Many of the faults shown are strike slip faults and are nearly vertical. If a fault is vertical, where will an earthquake epicenter be located?**

A. This cannot be determined. B. On the fault C. To the west of the fault D. To the east of the fault D. This would be a complex calculation.

**3. Locate the Hayward fault. What is likely to happen to the land east of the San Francisco Bay when it ruptures?**

A. Minimal disruption of structures, roads, and utilities. B. High disruption of structures, roads, and utilities. C. This cannot be determined just by looking at Google Earth.

**Cal Stadium**

*In Google Earth, double-click on “Cal Stadium.” (Leave “Bay fault Map” and “Labels” toggled on.)*

*Cal Stadium is famously located – discover why by examining this view with the Bay Area fault map turned on. Reconstruction of the stadium began in 2011.*

**4. If you were the engineer in charge, what would you have to take into account to increase safety of the stadium?**

A. A major fault cuts through the stadium. B. The nearby hills pose a hazard to the stadium. C. It is near the San Andreas fault, and so needs seismic strengthening. D. Nothing is obvious in this view.

**5. Look nearby at other buildings. How would you summarize the fault rupture hazard here?**

A. low – Everything is located in safe places. B. moderate – only a few structures are in harm’s way. C. high – many structures are in harm’s way. D. You cannot make such a determination from Google Earth.

**Sumatra 2004**

*In Google Earth: Toggle off “Bay Fault Map.” Double click on “Sumatra 2004.”*

*On December 26, 2004 a magnitude 9.1 earthquake occurred off the coast of Sumatra. This quake was on a subducting plate and generated a huge tsunami. Vegetation is growing back slowly in areas destroyed by the tsunami, but you may still be able to identify the tsunami damage zone. Turn on the historical imagery by clicking on the clock icon at the top of the Google Earth window. Use the slider bar to look at older imagery. Compare images before and after 12/2004.*

**6. What effects did the tsunami have here?**

A. It apparently did very little here. B. It created good farming soil, evidenced by the line of farms close to the coast. C. It destroyed buildings and tore out vegetation. D. It moved loose debris around, but did little else.

*Rotate and zoom the view a bit, and see if you can discover the highest marks left by the tsunami; measure the elevation at that location (it should be an elevation like a shoreline or high tide level).*

**7. How high did the tsunami get on the hills here?**

A. less than 40 feet B. 40 to 100 feet C. 100 to 150 feet D. >150 feet

*Zoom out and find Banda Aceh (to the NE). The coastal area was destroyed by the ‘04 tsunami. Turn on the historical photos tool and compare photos back to before 12/2004. Notice the locations of the greatest destruction by the tsunami.*

**8. What is the general relation between tsunami damage and proximity to coasts, bays, and rivers?**

A. none B. Closer to them and lower elevation means more damage. C. Damage appears to be random. D. You cannot make such an evaluation using Google Earth.

**9. So what do you conclude? How can people avoid tsunami property damage?**

A. It is unavoidable. B. Just locate far from the coast. C. You must be high above sea level. D. Build stronger structures.

**Kobe 1995**

*In 1995 a magnitude 6.9 earthquake hit Kobe, Japan. The intensity and the death and economic toll were unusually high for this size of an earthquake in modern Japan. Part of the problem may have been human caused. When engineers add rocks, soil, and debris to fill in shallow bays and increase the land area, they generally do so in rectangular patterns that contrast with natural curved and branching shapes. Bay fill (both natural and human made) liquefies during an earthquake.*

*In Google Earth double-click on ‘Kobe 1995’. Turn off historical imagery.*

*To assist you with #10 and #11 in the Earthquakes Guided Lab, please make the "25 Foot Contour layer visible. Everything between the red line and the ocean is at 25 feet of elevation or lower, meaning it is considered "fill".*

**10. How much of the shoreline of the bay in this region is fill? (Also check elevations; fill is everything below 25 feet elevation.)**

A. none B. a little C. less than half D. most

**11. Zoom in to Kobe. Fill is everything below about 25 feet elevation. How much of the development (buildings and roads) at Kobe is located on bay fill?**

A. less than 10% B. Maybe 10-25% C. Maybe 30-50% D. 90%

**12. Based on what you have studied in our text, what role will bay fill play in future earthquakes in this area?**

A. none

B. A few localized places may experience increased shaking and liquefaction.

C. Many small areas may experience increased shaking and liquefaction.

D. Increased shaking and liquefaction will be widespread.

E. Everything will be destroyed.

**Other 9.0 or greater earthquakes.**

*In Google Earth:*

* *Toggle on the “Magnitude 8 and Greater Earthquakes Since 1900” layer.*
* *Expand (click the ‘+’) “Magnitude 8 and Greater Earthquakes …”*
* *Toggle off ‘Magnitude 8’; Toggle on ‘Magnitude 9’ and ‘Earth’s Tectonic Plates.’*
* *Expand ‘Magnitude 9’ (click the +).*

**13. How many earthquakes of Mw 9 or greater have occurred in the world over the past 100 years?**

A. two B. three C. five D. ten E. >10

**14.** [half point each] **Choose one Mw 9 earthquake and double click on it to see where it occurred. What type of plate boundary is closest to it?**

A. convergent B. divergent C. transform

**Are there any earthquakes of Mw 9 or larger that occur on other types of plate boundaries?**

A. yes B. no

**15. Each of these Mw 9 and greater earthquakes caused a tsunami. Why do you think they did that?**

A. An earthquake that large causes large displacement on the fault, which moves the seafloor to cause

a tsunami.

B. The seismic waves are so strong in a great earthquake that they cause a tsunami.

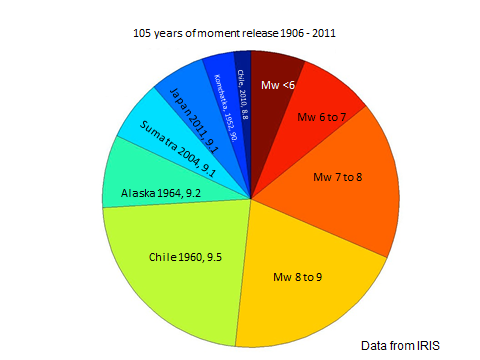
C. The plates involved are so massive that when they shake, they cause a tsunami.

D. It is coincidence.

**Extra: Discovering Earthquake Energy**

*An earthquake releases a tremendous amount of energy – the energy may destroy buildings, heave the earth into a permanent fault scarp, increase the height of mountains, or cause a tsunami. If we could capture the energy released by one earthquake, it would provide enough energy to supply the entire world’s energy needs for decades. The moment magnitude of an earthquake is an indication of how much energy is released; a moment magnitude 6 earthquake releases ~32 times more energy than a moment magnitude 5. The symbol Mw means moment magnitude. Figure 2 illustrates how the energy released by all earthquakes between 1906 and 2011 compare by magnitude.*

**Figure 2: 105 Years of Earthquake Energy Release, 1906 - 2011**

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Notice how many earthquakes are represented by the ~right half of the graph versus how many are represented by the ~left half.

*Now that you’ve completed this Discovery, you should feel confident to:*

* Determine where recent earthquakes occur and identify their plate tectonic setting.
* Do an initial seismic risk evaluation of an area based on fault maps.
* Identify the plate tectonic settings that are most at risk from very large earthquakes and tsunamis.
* Compare energy output from various earthquakes.