**Theoretician Instructions**

Name_______________________________

The theoreticians' task

1. Use the print-out provided by your teacher, or on a large piece of paper (11 x 17" paper will work), make a scale drawing of a half of Earth using a half circle with radius 20 cm (7.87 inches) — this represents a cross-section of earth at a scale of 1:20,000,000.

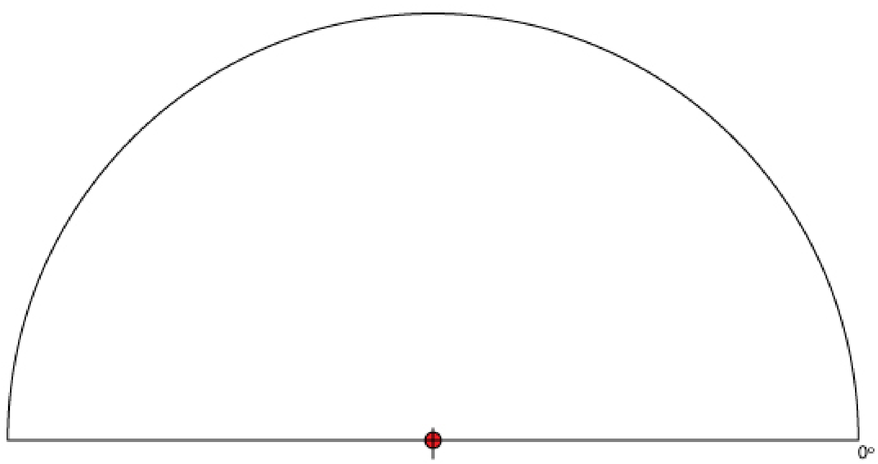
Orient your sheet sideways and place the origin of the circle near the bottom edge of the paper.

Organize a table of your predictions (i.e. your model data) that shows how the predicted earthquake travel time depends on the geocentric angle.

Include in your table:

- your raw distance measurements (in cm)
- geocentric angle from the Earthquake to the seismometer station
- computed distances
- travel times (in seconds)
- travel times (in minutes). This will simplify comparison with your seismologists and with other theory teams, i.e. 90 seconds is expressed as 1.5 minutes.

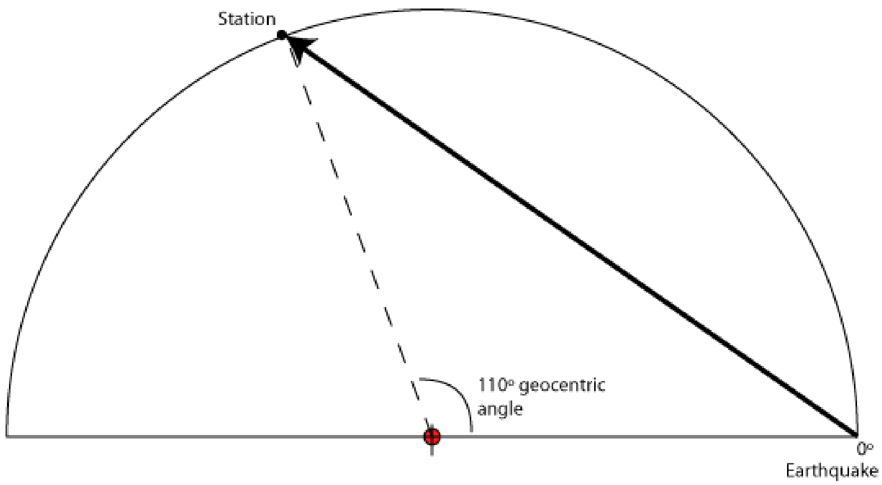
2. Assume an earthquake happens at 0° and is detected at several seismograph stations around the world. In this model, the earth is a perfect sphere and that seismic waves travel at a constant speed and in a straight line through the sphere, directly from the earthquake origin near the surface to the seismograph station on the surface part way around the earth.




3. Along Earth's surface (the curved part of the hemisphere), place several seismometer stations on your scale drawing at locations of your choice (hint: what range of angles do you want the model to cover? What is "enough" data?)

4. Draw the straight-line distance (the raypath) from the earthquake to seismometer and measure with a meter stick using centimeters (cm).

5. Measure the geocentric angle with your protractor.




6. Convert this distance to km using the known scale of the drawing.

Convert these measurements to kilometers (km) for the real Earth by multiplying by 320 (our scale factor of 1 cm = 320 km or 1:20,000,000 in the scale model diagram)

7. Convert to travel time assuming a constant speed of 11 km/sec for all distances (a fundamental assumption of this model that we are testing).

8. Be prepared to explain how you created diagram and your table of model predictions and to your fellow teammates. Discuss the assumptions of your model, how accurate you think your measurements are and what effect that has on your results, any difficulties you had and their likely impact on our results.

9. Plot your data of calculated times (y-axis) vs geocentric angle (x-axis) on the same graph paper as the seismologists. Draw a smooth curved line through the calculated travel times beginning from the graph's origin. Cooperate with them to determine the scale and make the plot. Be sure to label the axes and any lines drawn on your graph.

10. One or both teams may need to go back and add some additional model or data points to plot so that you get a good comparison.

Info you need:

- actual radius of the earth = 6371 km
- scale of your model 1:20,000,000 and 1km = 1,000,000 cm; thus the scale ratio is 1 cm to 20 km.
- * model scale (cm) to distance at Earth's scale (km): 6371 km /20 = 318.55 km =~ 320 km; 1 cm = 320 km
- ** assume a speed of seismic waves in constant velocity Earth of 11 km/s; divide length of raypath in km by velocity in km/s

**Theoretician data table**

| Geocentric Angle $\Delta$ (degrees) | Length of Raypath measured on diagram (cm) | Actual raypath length (km)* | Travel Time (s)** | Travel Time (min) |
|---|---|---|---|---|
| | | | | |

Questions to consider:

- Do the observed and calculated times differ significantly?
- What does this imply about our assumption that the Earth's interior might consist of a constant velocity of 11 km/s?

**Seismologist Instructions**

Name____________________

1. Use the Rapid Earthquake Viewer (REV) to access the international network of seismographs to gather data from real earthquakes and measure the observed travel times for the earthquakes to compare with the homogeneous Earth model being developed by the theoreticians' group. REV displays these data for earthquakes and seismic stations of your choice: http://rev.seis.sc.edu/

2. Collect earthquake data for a few earthquakes of interest. Think carefully about which data to use! Hint: look for large earthquakes above magnitude 6) with lots of stations where seismograms have been recorded so you will have a lot of data to create your graph. What issues of data quality will you need to consider?

Explore recent earthquakes of magnitude 6 or greater that are listed on the left side or click on "Earthquake view" and select one of the larger circles.

The next page will have a record section on the right side with green and blue seismograms displayed.

3. Examine the station data and find seismograms which have pronounced, or easily identifiable, P wave arrivals. You will record the station location, in terms of geocentric angle, for each station, and determine the travel time of the earthquake to the first sign of vibration at the seismograph (the arrival time of the P wave), using a ruler and the scale on the graph. (Real seismologists would have more precise plots to work with than you do here; just do your best). The REV time scale is hours:minutes:seconds. Note: The distance in km on the REV graphs is measured along Earth's surface, not the direct straight-line distance, so this is *not* the same distance that your theory team is working with.

To better see the data for a specific station, click on the station code in the list at the bottom. P wave arrival time may be read off the time scale adjacent to the seismogram. Using the "Select Zoom" feature around the P wave and the "overlay estimated P wave/S wave arrival times" toggle may assist the student in locating the P wave arrival time. It may be necessary to use the "add a station" function in order to get a more complete data set or compile data from several earthquakes.

4. Prepare a table of your data that shows how earthquake travel time varies with geocentric angle. To simplify comparison with your theorists and with other theory teams, express earthquake travel time in decimal minutes, i.e. 90 seconds is expressed as 1.5 minutes.

Be prepared to show your data and data table to the theory team and to discuss: how you chose your earthquakes, how accurate you think your travel time measurements are, any difficulties you had and their likely impact on your results.

5. Plot your data on the same graph paper as the theorists using the calculated times (y-axis) vs geocentric angle (x-axis). Cooperate with them to establish the scale of the graph and make the plot. One or both teams may need to go back and add some additional model or data points to plot so that you get a good comparison. Use very precise scaling, i.e., make a large graph. Be sure to label the axes and any lines drawn on your graph.

Questions to consider:

Do the observed and calculated times differ significantly? What does this imply about our assumption that the Earth's interior might consist of a constant velocity of 11 km/s?

How do travel times from stations at the same geocentric angle compare?

**Seismologist Data Table**

| Station Name | Distance along the surface (km) | Distance in Geocentric Angle | (optional) Length of Direct Raypath (km) | Travel time (min) |
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**Comment [seo1]:** I placed this in here because students can then see that the distance along the surface is not equal to the direct raypath.

However, it would take some explanation to show how to calculate this:

Side = 6371 km
Angle 1 = geocentric angle
Angle 2 and 3 = (180 – geoangle)/2

Equation
I don't know – where's my geometry book!