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Started on	Saturday, July 30, 2022, 3:45 AM
State	Finished
Completed on	Saturday, July 30, 2022, 7:57 AM
Time taken	4 hours 12 mins
Marks	35.67/42.00
Grade	**84.92** out of 100.00

Question 1
Correct
1.00 points out of 1.00
Flag question

For this assignment, you will be using IRIS's Local Seismogram Viewer (LSV) which can be found at http://ds.iris.edu/lsv/

This web app is being developed to help people review "record sections" of local recordings of moderate-sized earthquakes. Local in this context means within a few hundred kilometers, and moderate-sized means magnitude about 4 to 6. There are a set of earthquakes loaded into this app for you to choose from. Go ahead and click on the different events to bring up a plot that shows the "record section" for that earthquake. A record section is a plot of seismograms recorded at different distances from the earthquake, with the time plotted on the Y-axis going upwards. You can think of the different stations as a network, which provide information about how the Earth behaves more than a single observation can teach us. Seismic arrivals can be tracked across multiple stations to establish a travel time curve. You may recall we plotted predicted travel time curves using TauP in a previous assignment.

What are some general patterns that you observe when looking at the record sections for several earthquakes in the Local Seismogram Viewer?

Answer: As distance increases, travel time for P wave arrrival also increases from left to right

Check

Correct
Marks for this submission: 1.00/1.00.

Question 2
Correct
1.00 points out of 1.00
Flag question

For this assignment, I would like you to focus on the Magnitude 5.0 earthquake in Oklahoma on 08 Nov 2011 @ 02:46 UTC. I have found the recordings of this earthquake to be particularly representative. You should be able to find this event by zooming in on the map and clicking on the right circle. If you have trouble finding it, the direct link is here.

What is the depth (km) of this earthquake? You should see this information when you click on the earthquake.

Answer: 2.7

Check

Correct
Marks for this submission: 1.00/1.00.

Question 3
Correct
1.00 points out of 1.00
Flag question

When the record section comes up, there will be about 20 seismograms to review. What is the name of the station closest to the earthquake? (*We are looking for the 4-character code*)

Answer: V35A

Check

Correct
Marks for this submission: 1.00/1.00.

Question 4
Correct
1.00 points out of 1.00
Flag question

What is the time of first arrival? To correctly identify this time, first zoom into the arrival by clicking and dragging a shaded rectangle across the arrival. Then, gradually move your mouse along the seismogram until the symbol marking your cursor location moves to the right or left away from the baseline. Note that the popup window shows the time in tenths of seconds.

If you ever want to zoom back out, click the "Reset Zoom" button towards the top of the screen.

Answer: 6.5

Check

Correct
Marks for this submission: 1.00/1.00.

Question 5
Correct
1.00 points out of 1.00
Flag question

What is the distance of this station in kilometers? Although you can estimate distance along the X-axis, note that the popup window shows the precise distance.

Answer: 26.40

Check

Correct
Marks for this submission: 1.00/1.00.

Question 6
Correct
1.00 points out of 1.00
Flag question

The distance between the epicenter and the station (often called the epicentral distance) is not the true distance the seismic wave travels because the earthquake occurs below the surface. You can estimate the true distance by assuming the path is the hypotenuse of a right triangle where the depth and the epicentral distance are the lengths of the other sides of the triangle. Try to visualize this triangle in the Earth. Using the Pythagorean theorem for right triangles, what is the true distance the seismic wave travels (km)?

Answer: 26.53771

Check

Correct. Note that the depth value was so small relative to the epicentral distance, that the epicentral distance is actually a good approximation of the true distance for direct seismic waves.
Correct
Marks for this submission: 1.00/1.00.

Question 7
Correct
1.00 points out of 1.00
Flag question

Using the true distance and the arrival time, what is the velocity in km/s?

Answer: 4.082725

Check

Correct
Marks for this submission: 1.00/1.00.

Question 8
Correct
1.00 points out of 1.00
Flag question

What does this velocity represent?

Select one:
- a. velocity of the lowermost mantle
- b. velocity of the average mantle
- c. velocity of the uppermost crust ✓
- d. velocity of the lowermost crust
- e. velocity of the uppermost mantle
- f. velocity of the average crust

Check

Correct
Marks for this submission: 1.00/1.00.

Question 9
Correct
1.00 points out of 1.00
Flag question

Next you will measure the arrival times at several key stations where the Pn (early, small) and Pg (later, larger) arrivals are relatively clear. You should record the (epicentral) distance and time for each measurement in files called **Pn.txt** and **Pg.txt** on your OSL desktop so that we can perform linear regression on each (i.e., fit a line through the data). Log in to your OSL desktop and create a directory called network and then a directory called lsv. Which of the following commands would ensure you are in this directory once it is created?

Select one:
- a. cd ~/network/lsv ✓
- b. cd lsv
- c. cd /network/lsv
- d. cd network/lsv
- e. cd ~/lsv

Check

Correct
Marks for this submission: 1.00/1.00.

Question 10
Correct
0.67 points out of 1.00
Flag question

We will begin with the small first arrivals. Based on the instructions from the previous question and your knowledge of which arrival should be first, which file will these values be stored in on the OSL desktop?

Answer: Pn.txt

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 11
Correct
0.67 points out of 1.00
Flag question

We will now proceed to collect the distance and time information for the 6 stations mentioned in the following questions. I know that it may feel tedious to enter all this data in one at a time, but the purpose of this is to demonstrate the importance of checking your work during data collection. Our scientific results are only as good as our carefulness, so please bear this in mind when you are doing scientific work outside of our Moodle environment - check, double, triple check, to make sure things are correct before moving on.

Focusing on station U36A, what is the distance of this station in kilometers?

Answer: 134.20

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 12
Correct
1.00 points out of 1.00
Flag question

What is the first arrival time at this station?

Answer: 23.6

Check

Correct. **Make sure to record the distance answer from the last question and and the time answer from this question as the first two values on a single line in your Pn.txt file.** It should look something like this:
134.2 23.8
Correct
Marks for this submission: 1.00/1.00.

Question 13
Correct
0.67 points out of 1.00
Flag question

Now we will focus on the second arrival, but before we do, I want to make sure that you recorded the distance and time from the last two questions in the **Pn.txt** file. Then open a Pg.txt file and record the distance and answer to this question.

Now look at the seismogram again and identify what time is the second, larger arrival occurs at this station?

Answer: 25.3

Check

Correct. Now make sure to store the same distance value (answer to question 11) and the time answer to this question into the **Pg.txt** file. It would look like this:
134.2 25.3
Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 14
Correct
1.00 points out of 1.00
Flag question

Focusing on station U37A, what is the distance of this station in kilometers?

Answer: 178.20

Check

Correct
Marks for this submission: 1.00/1.00.

Question 15
Correct
1.00 points out of 1.00
Flag question

What is the first arrival time at this station?

Answer: 30.6

Check

Correct
Marks for this submission: 1.00/1.00.

Question 16
Correct
1.00 points out of 1.00
Flag question

What is the second arrival time at this station?

Answer: 32.8

Check

Correct
Marks for this submission: 1.00/1.00.

Question 17
Correct
1.00 points out of 1.00
Flag question

Focusing on station X39A, what is the distance of this station in kilometers?

Answer: 266.20

Check

Correct
Marks for this submission: 1.00/1.00.

Question 18
Correct
0.67 points out of 1.00
Flag question

What is the first arrival time at this station?

Answer: 42.5

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 19
Correct
1.00 points out of 1.00
Flag question

What is the second arrival time at this station?

Answer: 46.7

Check

Correct
Marks for this submission: 1.00/1.00.

Question 20
Correct
1.00 points out of 1.00
Flag question

Focusing on station MIAR, what is the distance of this station in kilometers?

Answer: 309.10

Check

Correct
Marks for this submission: 1.00/1.00.

Question 21
Correct
1.00 points out of 1.00
Flag question

What is the first arrival time at this station?

Answer: 47.9

Check

Correct

Marks for this submission: 1.00/1.00.

Question 22
Correct
0.67 points out of 1.00
Flag question

What is the second arrival time at this station?

Answer: 54.7

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 23
Correct
1.00 points out of 1.00
Flag question

Focusing on station 138A, what is the distance of this station in kilometers?

Answer: 352

Check

Correct
Marks for this submission: 1.00/1.00.

Question 24
Correct
1.00 points out of 1.00
Flag question

What is the first arrival time at this station?

Answer: 52.5

Check

Correct
Marks for this submission: 1.00/1.00.

Question 25
Correct
1.00 points out of 1.00
Flag question

What is the second arrival time at this station?

Answer: 61

Check

Correct
Marks for this submission: 1.00/1.00.

Question 26
Correct
1.00 points out of 1.00
Flag question

Focusing on station Q36A, what is the distance of this station in kilometers?

Answer: 396

Check

Correct
Marks for this submission: 1.00/1.00.

Question 27
Correct
1.00 points out of 1.00
Flag question

What is the first arrival time at this station?

Answer: 58.2

Check

Correct
Marks for this submission: 1.00/1.00.

Question 28
Correct
0.33 points out of 1.00
Flag question

What is the second arrival time at this station?

Answer: 66.4

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.33/1.00**.

Question 29
Correct
1.00 points out of 1.00
Flag question

Now that you have stored the data in the **Pn.txt** and **Pg.txt** files, make sure they are saved and you can exit them. You will perform linear regression on them using a GMT command called `trend1d`. You can run `trend1d` without any options to get a summary of this command. It is a little confusing at first because it has a wide array of trend fitting functionality. We will just be using it to fit a straight line with a slope. The format for this command when we run it will be:

```
gmt trend1d (filename) -N(number) -F(format) -V
```

The next few commands will walk through these parameters. The -N option asks us how many terms there are in polynomial function that we are fitting. Consider the equation form for a simple line with a slope: y = mx + b

How many terms are added together to describe the y value?

Answer: 2

Check

Correct, a slope term and a y-intercept term.
Correct
Marks for this submission: 1.00/1.00.

Question 30
Correct
1.00 points out of 1.00
Flag question

Another option that we need to decide on for `trend1d` is the -F option. I would recommend that we output the x value, the y value, and the modeled version of the y value so that we can see how close the predicted y value is to the actual y value. Which -F option would accomplish this?

HINT: You can just enter `gmt trend1d` on the command line to get some general information about the -F option and what format it uses.

Select one:

- a. -Fxyr
- b. -Fx/y/r
- c. -Fxyw
- d. -Fx/y/m
- e. -Fx,y,m
- f. -Fx,y,w
- g. -Fxym ✓
- h. -Fx/y/w
- i. -Fx,y,r

Check

Correct
Marks for this submission: 1.00/1.00.

Question 31
Correct
0.00 points out of 1.00
Flag question

The last option that we need to include when running `trend1d` is the `-V` option, which provides "Verbose" output for you to be able to see what the linear fit parameters are. Go ahead and run `trend1d` on the **Pg.txt** file first. Recall that I gave you the format for running this command a few questions ago.

When you run the command on the **Pg.txt** file it should produce a few lines that start with `trend1d:` and then the lines of your Pg.txt file with a third column that is the modeled value for your linear fit to your data.

Now focus on the line that starts like this:

```
trend1d: Model Coefficients (Polynomial):
```

On this line, there are two numeric values after the text. The first value is the y-intercept, the second value is the slope. What does the slope represent in terms of our data? HINT: Remember that we are fitting a line to travel time data. If you are having trouble remembering, look back to the webinar.

Select one:

- a. distance
- b. two-way travel time
- c. velocity
- d. slowness ✓ Precisely, the slope is the horizontal slowness based on the time per distance, which is the inverse of velocity (distance per time).
- e. arrival time

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.00/1.00**.

Question 32
Correct
1.00 points out of 1.00
Flag question

What is the slope reported for the **Pg.txt** file? Round off to at least 3 decimal places.

Answer: 0.155

Check

Correct
Marks for this submission: 1.00/1.00.

Question 33
Correct
0.67 points out of 1.00
Flag question

What is the velocity of the Pg wave? I will assume your answer is in km/s.

To answer this question, recall how the velocity is related to the slowness.

Answer: 6.451

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 34
Correct
0.00 points out of 1.00
Flag question

What does this velocity represent in general?

Select one:

- a. velocity of the uppermost mantle
- b. velocity of the lowermost crust
- c. velocity of the lowermost mantle
- d. velocity of the average mantle
- e. velocity of the average crust ✓ Correct - the Pg wave is a direct wave that goes from the source directly to the station, so it travels through the crust. Whether Pg travels through the upper crust or the lower and upper crust will depend on the depth of the earthquake - which is why we say it represents the velocity of the average crust.
- f. velocity of the uppermost crust

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.00/1.00**.

Question 35
Correct
0.67 points out of 1.00
Flag question

What is the slope for the **Pn.txt** file? Round off to at least 3 decimal places.

Answer: 0.128

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 36
Correct
1.00 points out of 1.00
Flag question

What is the velocity of the Pn wave? I will assume your answer is in km/s.

Answer: 7.8

Check

Correct
Marks for this submission: 1.00/1.00.

Question 37
Correct
0.67 points out of 1.00
Flag question

What does this velocity represent?

Select one:

- a. velocity of the uppermost crust
- b. velocity of the lowermost crust
- c. velocity of the average crust
- d. velocity of the average mantle
- e. velocity of the uppermost mantle ✓ Correct - the Pn wave is refracted at the Moho, so it travels through the uppermost part of the mantle.
- f. velocity of the lowermost mantle

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 38
Correct
1.00 points out of 1.00
Flag question

Next we should estimate the depth of the Moho - the boundary between the crust and mantle. Which of the waves is guaranteed to interact with the Moho?

Select one:

- a. Pn ✓ Correct - the Pn wave is refracted at the Moho.
- b. Pg
- c. both Pn and Pg
- d. neither Pn or Pg

Check

Correct
Marks for this submission: 1.00/1.00.

Question 39
Correct
0.00 points out of 1.00
Flag question

For the wave you chose in the answer to the previous question, the Y-intercept would represent the time for this wave at 0 distance. Physically it is impossible for this refracted wave to be observed at this distance because all the energy that refracts through the Moho at 0 distance is transmitted through the Earth and cannot find a way back to the surface. However, we can use the y-intercept to estimate the depth of the Moho using this equation:

$$Time\ (x=0) = 2 * h * (V_{Pn}^2 - V_{Pg}^2)^{1/2} / (V_{Pn} * V_{Pg})$$

where h is the depth and V are velocities for the different waves. It may seem like a complicated equation, but it is similar to the regular velocity equation (velocity = distance / time) but things are rearranged, and the velocity term takes into account the different speeds. And ultimately it is trying to represent the time it would theoretically take for a refracted wave to go straight down to the Moho and come back.

We will solve for the depth term, but first we need the Time at x=0.

What is the **y-intercept** value (Time at x=0) for this wave based on your `trend1d` output? Remember to focus on the `trend1d` output line that starts like this:

```
trend1d: Model Coefficients (Polynomial):
```

And make sure you are focusing on the output from running `trend1d` on the correct file.

Answer: 7.07

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.00/1.00**.

Question 40
Correct
1.00 points out of 1.00
Flag question

So how much time would it take to just go from the surface to the Moho?

Recall that the answer to the previous question is the time it takes to go from the surface to the Moho and back to the surface.

Answer: 3.535

Check

Correct
Marks for this submission: 1.00/1.00.

Question 41

Correct

1.00 points out of 1.00

Flag question

Using the equation and the velocities you measured earlier, what is the depth of the Moho in kilometers? To help you with this, I have rearranged the equation to solve for the depth (h):

$h = 0.5 * Time\ (x=0) * (V_{Pn} * V_{Pg}) / (V_{Pn}^2 - V_{Pg}^2)^{1/2}$

NOTE: The 1/2 exponent means to take the square root of the values inside the parentheses.

Answer: 40.58

Check

Correct
Marks for this submission: 1.00/1.00.

Question 42

Correct

1.00 points out of 1.00

Flag question

Do you think this is a reasonable estimate for the thickness of the crust in this part of North America? Why or why not? If you are unsure what the thickness of the crust should be in this area, you may find the USGS crustal model summary page helpful.

Answer: Yes, It is reasonable, because average thickness in North America for crust is about 36-37km so it a viable thickness.

Check

Correct
Marks for this submission: 1.00/1.00.

Finish review