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Started on	Wednesday, August 3, 2022, 7:49 AM
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Time taken	4 mins 34 secs
Marks	26.00/26.00
Grade	**100.00** out of 100.00

Question 1
Correct
1.00 points out of 1.00
Flag question

1. Requesting Seismic Data

In our activity today, we will obtain some real seismic data to continue learning how to use SAC to analyze seismic data. Before we get started with requesting the data, we should make sure we have a location to store our new data.

You will need to create a new directory called **sacdata** inside your **sac** directory. What is the correct order of commands below to create, check, and then enter this **sacdata** directory?

cd sacdata	4 ✓
ls sacdata	3 ✓
cd ~/sac	1 ✓
mkdir sacdata	2 ✓
cd ~/groupwork	Not needed ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 2
Correct
1.00 points out of 1.00
Flag question

An excellent resource for obtaining earthquake data is the Wilber webpage provided by IRIS. From this page you can choose datasets for a large variety of significant earthquakes, typically those greater than magnitude 5, but many smaller ones now have datasets for more recent events. The seismograms for all of the seismometers that record the event are grouped together and you can choose which observations you might like to access quickly.

For this example, we will examine data from a rare earthquake in the Gulf of Mexico that occurred on September 10, 2006. Because this is not a recent event, the first thing you need to do on the website is to find the drop-down box that says Past 30 days, M3.0+ (or Custom Query) in the upper right, and choose: **2006, M5.0+** from the drop-down choices. Then find the box labeled Magnitude on the right side of the website window and change the original minimum value of 5 to instead be **5.5**. You can select the event we want by using the map to zoom into the Gulf of Mexico, but you can also find it by selecting that exact day (2006-09-10) for both the beginning and ending Date on the right side of the website window. Looking at the table that is generated below the map, how many events of magnitude 5.5+ occurred on this day?

Answer: 1 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 3
Correct
1.00 points out of 1.00
Flag question

What was the magnitude of the Gulf of Mexico event?

Answer: 5.9 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 4
Correct
1.00 points out of 1.00
Flag question

If you have not already, take a minute to zoom in using the map view to see where this event occurred geographically. Which city was this event close to?

Select one:

- a. Houston
- b. None really, as the event was over 200 km from land. ✓
- c. Cancun
- d. New Orleans
- e. Tampa

Check

Correct
Marks for this submission: 1.00/1.00.

Question 5
Correct
1.00 points out of 1.00
Flag question

Next, click on the Gulf of Mexico event in the table to start selecting seismic stations that recorded this earthquake. The stations are shown on the map and in the table below it. By default, the only stations that are shown are from the Global Seismic Network (GSN). Since this event was near the United States, I would like you to select some stations from the US: United States National Seismic Network (USNSN). To do this, first click the X next to the _GSN button in the Network box on the right side of the website window. Then when you click in the Network box, you should be able to choose the US network code that represents the United States National Seismic Network. Looking at the table that is generated below the map, how many stations in the US network recorded this event?

Answer: 67 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 6
Correct
1.00 points out of 1.00
Flag question

For this example, I would like you to focus on 3 stations: ACSO, ISCO, and HLID. To select just these 3 stations, I would recommend that you click the None button at the top of the table, and then scroll down through the table to check the box for these 3 stations. Using the right-most column in the table, where is station HLID located?

Select one:

- a. Alum Creek, Ohio
- b. Idaho Springs Colorado
- c. Hopedale, Illinois
- d. Hailey, Idaho ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 7
Correct
1.00 points out of 1.00
Flag question

Next we need to choose which seismometer recordings we want from these stations. We do this with the Channel box on the right side of the website window. Seismometer channels are defined with a 3 character code where the first character describes the sampling rate, which defines whether recorded signals capture high, low, or broadband frequencies. This is typically L for low, B for broadband, and H for high. The second character describes the gain, which is the degree to which the amplitude is amplified. For weak signals that come from all over the globe, we typically want H for high-gain. For strong motions that come from earthquakes very close to the recorder, we typically want N that indicates an accelerometer motion sensor, like those in your phone or laptop. The third character describes the orientation of the sensor. This is typically Z for Up-Down, N for North-South, and E for East-West. When making a request, we often want all three orientation recordings, so we can use a ? to indicate that we would like all available orientations. What is the default option listed in the Channel box on the Wilber page?

Answer: BH? ✓

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 default Channel option represent?

Select one:

- a. Broadband frequencies, high-gain amplification, and all horizontal orientations
- b. Big amplification, high frequencies, and all horizontal orientations
- c. Big amplification, high frequencies, and all available orientations
- d. Broadband frequencies, high-gain amplification, and all available orientations ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 9
Correct
1.00 points out of 1.00
Flag question

Next click Request Data. If nothing happens, you have a java problem (see the troubleshooting document for tips on fixing this). A Build Data Request window should come up on your screen to allow you to choose some specifics about the data request.

- For the Time Range, you should choose ***5 minutes before the P***, and ***20 minutes after the P***.

- For the Data Output, you should choose ***SAC binary (little-endian)***, and then choose ***gzipped tar archive*** under ***Bundle As***. Choosing this option is easier for downloading files as all of the files will be bundled as one instead of having to download each file individually.

- In the Request Information, you should enter ***your Moodle login username*** (e.g., mine is brudzmr) and a request label of ***florida06***.

Some additional information about Output Format: I am asking you to download data in SAC binary (little-endian) format. As you learned in the previous tutorial, SAC stands for Seismic Analysis Code and is a general purpose interactive program designed for the study of sequential data, especially time-series data. SAC files contain both the data and metadata. That means it has both the amplitudes over time (data) and information about how that data was collected (metadata). While we typically focus on data in classes, scientists need to know the metadata to ensure their analysis is correctly reported and interpreted. The newest versions of Wilber allow users to download just the data files without most of the metadata. For SAC binary files, there are 2 types of byte orders listed: little-endian and big-endian (endian just refers to the ordering of bytes). In technical terms, for Little-endian byte order the least significant byte (the "little end") of the data is placed at the byte with the lowest memory address while for the big-endian byte order the most significant byte (the "big end") of the data is placed at the byte with the lowest memory address. I am having you choose the little-endian byte order because it is formatted for use on a Linux PC, whereas big-endian binary files are not. If you click on the Output Format you will see there are a few options for downloading SAC files in addition to a few others, what are some of the choices you get? Choose all that apply.

Select one or more:

- ☑ a. ASCII: 2 column ✓ Correct, this file will simply be a series of time and amplitude values for data points without any metadata. The data file is large because it is not compressed, but it can be useful for importing seismic data into other programs besides SAC.
- ☑ b. SAC binary (little-endian) ✓ Correct, this type of binary file if formatted for use on a Linux PC, whereas big-endian binary files are not. Binary files are smaller than ASCII files because they are compressed, but you cannot look inside with a text editor to see the data points. It contains a small amount of metadata.
- ☑ c. miniSEED ✓ Correct, this is a highly compressed form of binary data that is similar to SEED but without the metadata. It is growing in popularity, but it cannot be read by SAC directly.
- ☑ d. SAC ASCII ✓ Correct, this file can be read directly into SAC, but the files are larger than binary files because the file is uncompressed plain text. It contains a small amount of metadata.
- ☑ e. ASCII: 1 column ✓ Correct, this file will simply be the amplitude data points print out in a stream of numbers. It assumes that you know what the sampling rate of the data is to know what the time values are associated with the amplitudes it provides. This can be useful for using seismic data in other programs besides SAC.

Check

Correct
Marks for this submission: 1.00/1.00.

Question 10
Correct
1.00 points out of 1.00
Flag question

2. Retrieving Seismic Data

Then down at the bottom of the page, you can click Submit to process your request. You should receive an email confirmation, and then you will receive a second email about 1 minute later indicating the data is available for you to download. Inside your OpenSARlab desktop, you can access the Internet and then log into your email. Click the icon that looks like a globe and a mouse pointer at the bottom of your screen to open a web browser.

Inside the second email, you should find a part that provides you with a DIRECT LINK to your data file that should look something like this:

http://ds.iris.edu/pub/userdata/wilber/Mike_Brudzinski/florida06/florida06.tgz

Your link will look slightly different because it should have your name in the filename. We will use this link to get your data file on to your linux machine. Copy your link into a command that looks like this:

wget "http://ds.iris.edu/pub/userdata/wilber/Mike_Brudzinski/florida06/florida06.tgz"

You can right-click to copy-paste in OpenSARlab. If you're using a Mac, you can enable right-click on a Mac by going into System Preferences -> Trackpad -> Point & Click -> Secondary click: click in bottom-right corner.

Remember, that your command will have different username in the filename, which you would get from your email. Which of the following responses did you receive when you run your wget command?

Select one:

- a. No response
- b. wget all done
- c. A response that ends with a line that has "`florida06.tgz' saved" in it. ✓
- d. ERROR 404: Not Found.

Check

Correct
Marks for this submission: 1.00/1.00.

Question 11
Correct
1.00 points out of 1.00
Flag question

3. Unpacking Seismic Data

After the .tgz file has successfully transferred to your computer, ls should help you see that your .tgz file is now on your machine.

```
(iris) jupyter-[your username]:~/sac/sacdata> ls
```

This ls command should show your florida06.tgz file you just downloaded. If not, please review the commands from the previous question to make sure you retrieve this file. You can unpack (unzip) individual SAC data files from the .tgz archive using the `tar` command. The options we are going to use are -xzvf .

- x = tells `tar` to extract files from an archive (e.g., florida06.tgz)
- v = tells `tar` to list the files processed from the archive (e.g., florida06.tgz) as the output of the command
- z = tells `tar` to filter the archive (e.g., florida06.tgz) through **gzip**
- f = tells `tar` what the name of the archive file is (e.g., florida06.tgz)

You can read more about this command with `man tar`. Now type the following:

```
(iris) jupyter-[your username]:~/sac/sacdata> tar -xzvf florida06.tgz
```

The files extracted from florida06.tgz should be shown on your screen. Next type `ls` to see what was extracted from florida06.tgz

```
(iris) jupyter-[your username]:~/sac/sacdata> ls
```

Which of the following are listed in your sacdata directory?

Select one or more:

- ☐ a. SAC files
- ☐ b. No files or directoires listed.
- ☑ c. florida06/ ✓ 1 of 2 Correct. This is the directory that contains your SAC files.
- ☑ d. florida06.tgz ✓ 1 of 2 Correct. This is your zipped file.

Check

Your answer is correct.

Correct
Marks for this submission: 1.00/1.00.

Question 12
Correct
1.00 points out of 1.00
Flag question

Next, enter the florida06/ directory to see your extracted SAC data files.

```
(iris) jupyter-[your username]:~/sac/sacdata:~> cd florida06
(iris) jupyter-[your username]:~/sac/sacdata/florida06> ls
```

How many .SAC files were produced?

Answer: 9 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 13
Correct
1.00 points out of 1.00
Flag question

Now we can read these files into SAC. Each file contains a single seismogram. For seismic data this means a single data channel recorded at a single seismic station.

```
(iris) jupyter-[your username]:~/sac/sacdata/florida06> sac
SAC> r *.SAC
SAC> p1
```

Which station and component (e.g., BHZ) appear first in SAC?

If you have trouble reading the names of the stations or components, you can try running these commands:

```
SAC> gtext size large
SAC> p1
```

Note: There is a chance gtext will not work with so many seismograms being displayed at once. You can increase the size of the window containing the plots by dragging one of the corners. You can also play around with the size of the desktop display by going into Applications (in the top left corner) -> Settings -> Display, and then changing the resolution and clicking Apply. By default, the resolution of the desktop is 1680 x 1050, but feel free to find one that works best for you!

Select one:

- a. HLID BHE
- b. ACSO BHZ
- c. ISCO BHN
- d. ISCO BHE
- e. HLID BHZ
- f. ACSO BHN
- g. ACSO BHE ✓
- h. HLID BHN

i. ISCO BHZ

Check

Correct
Marks for this submission: 1.00/1.00.

Question 14
Correct
1.00 points out of 1.00
Flag question

When we requested the data, we asked for 5 minutes before the P wave. SAC plots seismograms with the X-axis in seconds. At what time should we see the first P wave?
If the seismograms are difficult to see, please refer to the instructions in Question 13 to increase the size of the plots.

Answer: 300 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 15
Correct
1.00 points out of 1.00
Flag question

Does the first P wave arrive at about that time?
Note: Since we requested quite a lot of data, the tick marks on the x-axis are scaled. You can find the scale in the bottom left corner of your plot. By default, the scale is 10+2, meaning each tick mark labeled 1, 2, and so on represent 100, 200, etc. seconds.

Select one:
- a. Yes, it arrives at that time on station HLID
- b. No, it arrives at an earlier time
- c. Yes, it arrives at that time on station ISCO
- d. Yes, it arrives at that time on station ACSO ✓
- e. No, it arrives at a later time

Check

Correct
Marks for this submission: 1.00/1.00.

Question 16
Correct
1.00 points out of 1.00
Flag question

You should have noticed by now that the P wave does not arrive at the same time at all of the stations. This should be expected considering the earthquake occurred in the Gulf of Mexico and our stations are located in Ohio, Colorado, and Idaho. Because we requested the data to be 5 minutes before the P wave, each seismogram should start 5 minutes before the P wave. At what time (in seconds) does a seismogram for ISCO start in this view?
Reminder: you are not looking for the start of the P wave as you found in Question 14. You are looking for the start of the seismogram trace.

Answer: 80 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 17
Correct
1.00 points out of 1.00
Flag question

Based on this approach, how much later is the P wave at station HLID than ACSO?

Answer: 150 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 18
Correct
1.00 points out of 1.00
Flag question

It may be a little difficult to see the exact time of the first P wave arrival in the current view of the entire seismogram. It would help if we could zoom in around the first P wave arrival to see it more clearly. While you could use PPK to do this in an interactive way, the XLIM command can be used to specify a new range for the X-axis. The format for this command is:

```
SAC> XLIM [Xmin] [Xmax]
```

where [Xmin] and [Xmax] are the minimum and maximum values of the new X-axis range.
Which of the following would change the SAC plot so that you can see the when the first P wave arrives more clearly?

Select one:
- a. XLIM -25 25
- b. XLIM 275 325 ✓ Correct. Please run this command now if you have not already.
- c. XLIM 300 350
- d. XLIM 300 50
- e. XLIM 0 300
- f. XLIM 250 300

Check

Correct
Marks for this submission: 1.00/1.00.

Question 19
Correct
1.00 points out of 1.00
Flag question

Now go ahead and apply the correct XLIM command from the previous question if you have not already and then P1 to see the zoomed view of the seismograms. What is the approximate maximum value on the X-axis?

Answer: 480 ✓

Check

Correct. While you might have expected it to be 325, SAC reads those XLIM maximum numbers to represent 325 seconds into each seismogram. Since the seismograms from the 3 different stations start at different times, 325 seconds into those seismograms represents a later time for the ISCO and HLID stations. If you add 325 seconds to the later start time of HLID (155), you get 480. I realize this is confusing, so please read through this explanation once more before moving on to the next question.
Correct
Marks for this submission: 1.00/1.00.

Question 20
Correct
1.00 points out of 1.00
Flag question

The way that SAC plots times can be a little confusing, so perhaps I can help clarify things a little bit by asking you to plot using the RELATIVE option instead of the default ABSOLUTE option. By default, SAC plots all seismograms based on their absolute times, which can be very helpful because we often want to know the time difference between arrivals at different stations to determine earthquake locations. But in some cases, it is fine to plot seismograms relative to one another. You can do this by typing:

```
SAC> p1 rel
```

What is the maximum value on the X-axis now?

Answer: 50 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 21
Correct
1.00 points out of 1.00
Flag question

SAC should now be showing you the section of seismogram from 275 to 325 seconds for each station and component. This may be hard to tell just from looking at the X-axis in the plot window, because it should say from 0 to 50, but this represents the data from 275 to 325 seconds after the beginning of the seismogram. This is why the RELATIVE view can be more complicated than ABSOLUTE. The advantage is that you should have a zoomed in view around the 300 second mark of each seismogram. What does this view look like?

Select one:
- a. A clear peak in the middle of the view on seismograms for station ISCO that represents the P wave
- b. A clear peak in the middle of the view on seismograms for station ACSO that represents the P wave
- c. A clear peak in the middle of the view on seismograms for station ISCO that represents the S wave
- d. A clear peak in the middle of the view on all seismograms that represents the S wave
- e. A clear peak in the middle of the view on seismograms for station HLID that represents the P wave
- f. A clear peak in the middle of the view on all seismograms that represents the P wave ✓
- g. A clear peak in the middle of the view on seismograms for station HLID that represents the S wave
- h. A clear peak in the middle of the view on seismograms for station ACSO that represents the S wave

Check

Correct
Marks for this submission: 1.00/1.00.

Question 22
Correct
1.00 points out of 1.00
Flag question

In order to return to the original X-axis range that covers the entire seismogram you need to specify:

```
SAC> xlim off
SAC> p1
```

Although you have returned to the original X-axis limits that will show the entire seismograms, the RELATIVE option is still set for the P1 command. Recall that options such as this for action-producing commands are changed until the program is terminated. If you QUIT from SAC and start it again, the option will be reset to ABSOLUTE. Considering that the RELATIVE option is still set, what is different from the ABSOLUTE view we saw earlier? You are welcome to try P1 ABSOLUTE if you cannot recall how the P1 RELATIVE plot is different.

Select one:
- a. For the ABSOLUTE option, all seismograms are plotted starting at zero time, so you cannot see the offset in time between the P waves at different stations.
- b. For the RELATIVE option, all seismograms are plotted starting at zero time, so you cannot see the offset in time between the P waves at different stations. ✓ Correct. For the remainder of the questions, it would help to switch the option back, so please enter P1 ABSOLUTE into SAC.
- c. For the RELATIVE option, all seismograms are plotted starting at zero time, but you can still see the offset in time between the P waves at different stations.
- d. For the ABSOLUTE option, all seismograms are plotted starting at zero time, but you can still see the offset in time between the P waves at different stations.

Check

Correct
Marks for this submission: 1.00/1.00.

Question 23
Correct
1.00 points out of 1.00
Flag question

The Y-axis can also be specified with the YLIM command with the same format:

```
SAC> YLIM [Ymin] [Ymax]
```

where [Ymin] and [Ymax] are the minimum and maximum values of the new Y-axis range applied to all seismograms.

This can be helpful in some cases because the default setting in SAC is to scale the Y-axis automatically to the largest amplitude in each seismogram. Notice that in your current view, each seismogram fills the entire section of the plot it is in because the Y-axis values are adjusted to exactly the right range for that seismogram. It may be difficult to read the Y-axis range values for two reasons: 1) they are written in small text and 2) they are written in an odd exponential format. The X 10+3 next to many of the Y-axes indicates the values on the Y-axis should be multiplied by 10 to the 3rd power (1000). So the values on the ISCO BHZ Y-axis represent -2000, 0, and 2000. *If you are having difficulty seeing the labeled values, you can use **p** instead of **p1** to view one seismogram at a time.*

What is the largest positive Y value label you can find in your current SAC plot? Please write the actual number, not the exponential format that SAC uses.

Answer: 60000 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 24
Correct
1.00 points out of 1.00
Flag question

You can also have SAC plot all of the seismograms with the same Y-axis range by specifying:

```
SAC> ylim all
SAC> p1
```

Forcing the same Y-axis range can be helpful for seeing the relative sizes of the different seismograms. Which seismogram has the largest amplitudes?

Select one:
- a. ACSO BHN ✓
- b. HLID BHZ
- c. ACSO BHE
- d. ISCO BHZ
- e. HLID BHE
- f. ISCO BHN
- g. HLID BHN
- h. ISCO BHE
- i. ACSO BHZ

Check

Correct
Marks for this submission: 1.00/1.00.

Question 25
Correct
1.00 points out of 1.00
Flag question

In order to return to the original X-axis range that covers the entire seismogram you need to specify:

```
SAC> ylim off
SAC> p1
```

You should see the original view of the 9 seismograms like we started with.
The O marker in SAC is used to denote the Origin time of the earthquake. At what time is the O marker relative to the beginning of the seismogram with the earliest P wave arrival?

Answer: 100 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 26
Correct
1.00 points out of 1.00
Flag question

Approximately how much time is there between the origin time and the first P wave recorded?

Answer: 200 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Finish review