

Tides

To solve problems, scientists ask scientific questions. They determine the best methods to answer the question, collect the data, and analyze it to draw evidence-based conclusions that answer the question. You will be practicing these steps in the process of science in this lab.

Learning objectives:

- Students will be able to use data to describe how and why the sea level changes as a result of tides.
- Students will be able to apply and analyze steps in the **process of science** (scientific literacy).
- Students will be able to **read graphs** (quantitative literacy).
- Students will be able to distinguish between **causation and correlation relationships** (scientific literacy).
- Students will be able to calculate **averages** (quantitative literacy).

Materials needed:

- Access [NOAA Tides and Currents](http://tidesandcurrents.noaa.gov) (<http://tidesandcurrents.noaa.gov>)



Boats stranded without water during low tide (source: diego_torres on pixabay.com)

Part 1: Navigating NOAA Tides and Currents

Tides are the daily rise and fall of the sea level related Earth's rotation and the pull of gravity between Earth and the Moon. In this lab, you will collect and analyze data related to the sea level changes caused by tides.

Examine the [NOAA Tides and Currents](http://tidesandcurrents.noaa.gov) website by the National Oceanic and Atmospheric Administration (NOAA). If you click on a state and zoom in, you can see "pins" for different stations. To find a specific station, you can search for the station number or name.

In the “Search” bar on the left **Search:** , type “8665530” for the Charleston, South Carolina station. Click on “Station Home” at the top, then “Tides/Water Levels” then “Water Levels”. For help, watch the [Tides & Currents Map Tutorial Video](#).

Scientists use graphs to interpret data because they turn numbers into visual patterns that are easier to understand. They help communicate data by showing trends and patterns and making comparison easier. To **read a graph**, start by examining the labels to understand what the axes represent. Then look at the data points to identify trends, patterns, or comparisons.

You will see two days of water level data for the Charleston, SC station. Water levels are measured relative to the Mean Lower-Low Water level (MLLW), which is the average height of the lowest tide recorded each day.

1. Read the graph. What are the two different color lines?

- ☐ The green line is verified tide level, and the purple line is the difference between the observed and predicted water level.
- ☐ The blue line is the MHHW (mean higher high water), and the red line is the MLLW (mean lower low water).
- ☐ The blue line is the predicted water level, and the red line is the preliminary data for the actual water level.
- ☐ The red line is for Charleston SC, and the green line is for the next closest station (Fort Pulaski, Georgia) for comparison.

2. When you read the graph, how would you describe the trends and patterns shown?

- ☐ The height in feet on the left axis indicates that the size of the waves expected over two days increases and decreases.
- ☐ The lines indicate the water level goes up and down two times each day, measured in feet.
- ☐ The times are measured in hours and minutes, while the lines are measured in MLLW, which is a unit of degrees.
- ☐ The seven lines on the right indicate that the water level is predicted to remain the same in the future.

Do some brief independent research to learn more about the difference between diurnal, semidiurnal and mixed tides and where they occur in the US.

3. Based on the description of the three different types of tides, what type of tides are in Charleston, SC?

- ☐ Diurnal tides
- ☐ Semidiurnal tides
- ☐ Mixed tides

To find the water level during any six-minute interval, hover your cursor over the line, and the water level and time will appear. For the Charleston station, use the blue line to measure the predicted heights of three high tides (peaks) and three low tides (low points) and record them below in Data Table 1.

Scientists calculate **averages** to get more accurate results by reducing differences that happen by chance and error in measurements. You will take multiple measurements and average them together. To calculate the average, add up your measurements, then divide by the total number of measurements (in this case, 3).

Data Table 1

	Measurement 1 (ft)	Measurement 2 (ft)	Measurement 3 (ft)	Average height (ft)
High tide:				
Low tide:				

4. How did you calculate the **average** high tide and low tide?

- ☐ For each row, I added together each of the 3 measurements.
- ☐ For each column, I added together each of the 2 measurements.
- ☐ For each row, I added together 3 measurements and divided the total by 3.
- ☐ For each column, I added together 2 measurements and divided the total by 2.
- ☐ For the table, I added together each measurement and divided by 6, one for each measurement in the table.

5. What is the **average** high tide that you calculated in Data Table 1? _____ ft

The tidal range is the difference in height between the high and low tide. To calculate the tidal range, subtract the average low tide height from the average high tide height.

6. What is the average tidal range for this station? _____ ft

Part 2: Collecting data about the timing of tides

? How long is it from one high tide to the next in Charleston, SC?

Consider the scientific question above about the timing of tides. Using [NOAA Tides and Currents](#), you will collect data to answer this question. The methods to collect data have been figured out for you, but you will need to collect the data and analyze it to use as evidence to critically think about the conclusion proposed below.

Fill out Data Table 2 below with the predicted times for the 1st, 2nd, and 3rd high tide and calculate the average. Be sure that you carefully determine when the tide is at its highest.

Data Table 2

1 st high tide time	2 nd high tide time	3 rd high tide time	Time between 1 st and 2 nd high tide	Time between 2 nd and 3 rd high tide	Average time between consecutive high tides
			_____ hrs _____ min	_____ hrs _____ min	_____ hrs _____ min

7. What is the **average** time from one high tide to the next in Charleston, SC?

- ☐ 6 hours
- ☐ Between 11 and 12 hours
- ☐ 12 hours
- ☐ Between 12 and 13 hours
- ☐ 24 hours

A student proposes the conclusion “**There are 12 hours on average from one high tide to the next, resulting in a tidal cycle that lasts exactly one day.**”

8. Based on the data you collected in Data Table 2, how would you fix the student’s statement?

- ☐ On average, there are 11 hours and 30 minutes from one high tide to the next, resulting in a total cycle that lasts less than one day.
- ☐ There are 12 hours and 25 minutes on average from one high tide to the next, resulting in a total cycle that lasts more than one day.
- ☐ There are 24 hours on average from one high tide to the next, resulting in a total cycle that lasts exactly one day.
- ☐ I would not change it: There are 12 hours on average from one high tide to the next, resulting in a tidal cycle that lasts exactly one day.

Do some brief independent research to learn about the reason for the timing of tides.

Scientists distinguish between **causation versus correlation** relationships. Causation is where changing one thing directly produces a change in the other. In comparison, a correlation is where two things change together, but one does not necessarily cause the other or make the other happen. To tell if a relationship is causation or correlation, you need to understand the process that links the two things and what is making the changes happen.

9. All of these are examples of correlation, and two show causation. Which two describe **correlation** AND **causation**?

- ☐ There is a correlation between the timing of low tides and more seashells to find on a beach.
- ☐ There is a correlation between timing between high tides and the time between when people eat meals.
- ☐ There is a correlation between the timing of high tides and deeper water for sailboats.
- ☐ There is a correlation between the timing of low tides and the position of the Moon around Earth.

10. Think about your independent research. What is the **causation versus correlation** relationship between Earth's rotation and the timing of the tides each day?

- ☐ There is a causation relationship: Earth's rotation causes regular intervals of time between high and low tides each day because Earth rotates beneath the Moon.
- ☐ There is a causation relationship: The regular interval of time between high and two low tides each day cause Earth's rotation because of the Moon's gravitational pull.
- ☐ There is a correlation relationship: The regular interval of time between high and low tides correlates with the Earth's rotation, but one does not cause the other. They have a separate cause.

The Moon rises 50 minutes later each day. This is because the Moon orbits Earth, so the Earth needs to rotate a little extra for a location to be at the same point to see the moon rise again.

11. How do your data in Data Table 2 and the information about the timing of when the Moon rises illustrate the **causation versus correlation** relationship between the timing of high tides and the timing of the Moon rising?

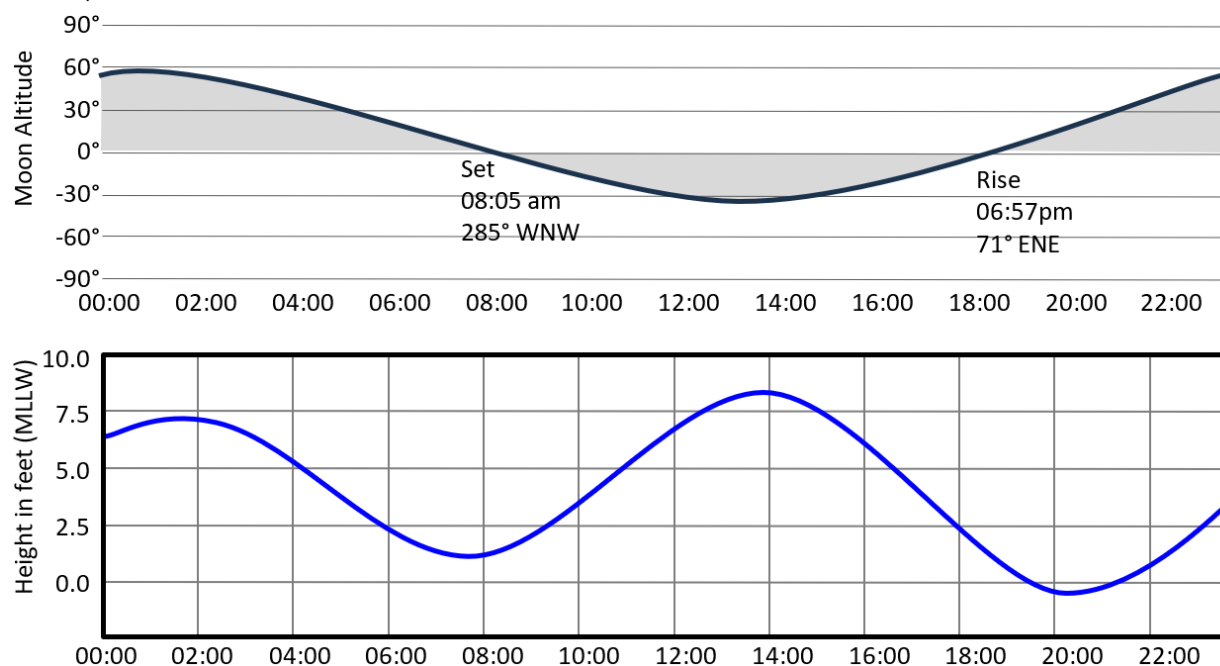
- ☐ There is a causation relationship: High tides occur later each day, causing the Moon to rise later.
- ☐ There is a causation relationship: The Moon rises later each day, causing high tides to occur later each day.
- ☐ There is a correlation relationship: High tides and the Moon rise are later each day, but the rotation of the Earth causes the timing of both.

12. Your friend is writing a mystery novel where the characters search for clues along the coast every night at midnight because the tides are low. Why wouldn't this strategy work?

- ☐ The tides are always high at midnight, so they would need to go out at sunrise or sunset.
- ☐ The tides are halfway between low and high at midnight.
- ☐ The time of low tide shifts later every day, so it is not always low tide at midnight.

Part 3: Analyzing data relating tides and the Moon's position in the sky

Below are graphs from [Time and Date](#) (top graph) and [NOAA Tides and Currents](#) (bottom graph) for Port Orford, OR.



13. Read the graph from Time and Date (top). What does the graph show?

- ☐ The Moon's height above and below the horizon over one day
- ☐ The altitude that airplanes can take off and land by time of day
- ☐ The direction that the Moon rises and sets each day for a month
- ☐ Water level over one day
- ☐ Diurnal tides

14. When you read the graph from Time and Date (top), what best describes the data shown in words?

- ☐ The Moon is at the highest in the sky just after midnight, it is below the horizon from 8 am to 7 pm, and it nears the highest point again just before midnight.
- ☐ The Moon sets before it rises each day of the month.
- ☐ The Moon moves in a wave-like motion across the sky between when it rises and sets, reaching an altitude of 60°.
- ☐ The water has waves that are 60° at their highest point just after midnight, with a wavelength of 10 hours.

15. Read the graph from Tides and Currents (bottom). What does the **graph** show?

- ☐ The moon's height above the horizon over time.
- ☐ The Moon's height above and below the horizon over one day.
- ☐ Water level over one day.
- ☐ How water wavelength changes with the direction of tidal currents.
- ☐ The direction that the Sun rises and sets each day for a month.

16. When you **read the graph** from Tides and Currents (bottom), what best describes the data shown in words?

- The waves are close together and steep, reaching a height of about 8 feet in the early afternoon at 14:00.
- Just after midnight, the waves occurred 2 minutes apart, but by the end of the day close to midnight, the waves were 22 minutes apart.
- The direction that the waves are coming from changes over the course of a day, starting just after midnight from the northwest and ending from the southwest.
- The tide is high just after midnight, it is low around 8:00, it is high around 14:00, it is low around 20:00, and it's rising again close to midnight.

? How does the Moon's position in the sky relate to semidiurnal tides?

Consider the scientific question above about the relationship of the Moon's position in the sky and tides. A student used [Time and Date](#) and [NOAA Tides and Currents](#) to collect the following two days of data to answer the question.

Data Table 3

Moon's position in the sky	Tide
Highest point	High
Horizon (setting)	Low
Lowest point, below the horizon	High
Horizon (rising)	Low
Highest point	High
Horizon (setting)	Low
Lowest point, below the horizon	High
Horizon (rising)	Low

17. Think about **causation versus correlation**. What correlational relationships can be identified with these data?

- When the tide is high, the Moon's position is at its highest or lowest points; when the tide is low, the Moon is on horizon.
- When the Moon's position is high in the sky, the tides are high; when the Moon's position is low in the sky, the tides are low.
- There is no correlation between the Moon's position and tide height.

18. Think about **causation versus correlation**. What causal relationship between the Moon's position and high tide can be identified?

- When the tides are high, it causes the Moon's position to be high in the sky.
- When the Moon's position is below the horizon, the tides are high, but when the Moon's position is on the horizon, the tides are low.
- When the Moon's position is highest or lowest in the sky, it causes the tides to be high.
- There is no causation between the Moon's position and tide height.

19. What part of the **process of science** did you do when you determined the relationship between the Moon's position and tides based on the data in the table?

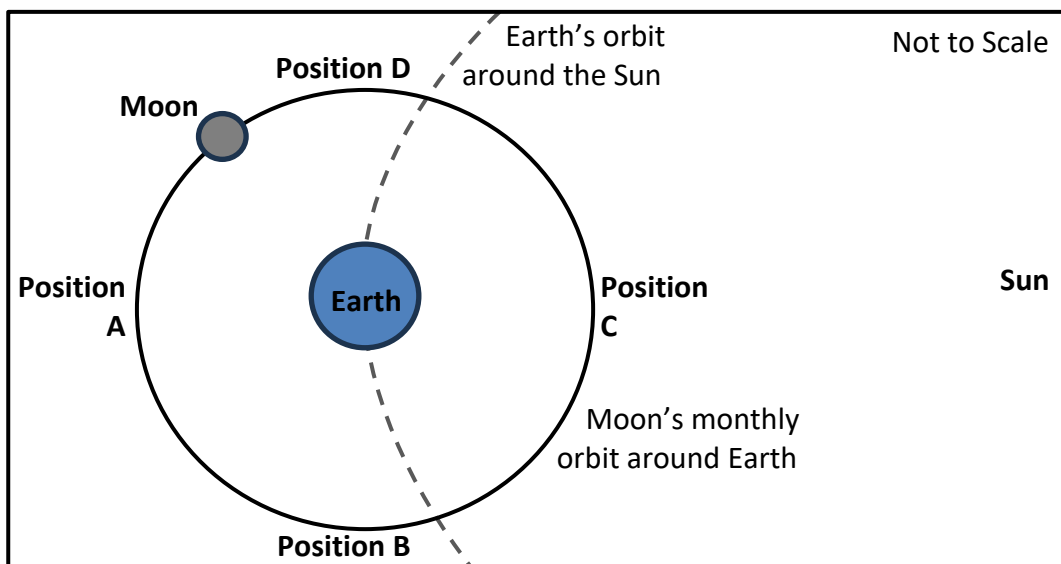
- ☐ Ask a scientific question
- ☐ Determine the methods to use
- ☐ Make observations and collect data
- ☐ Analyze data and develop conclusions
- ☐ Share results and conclusions

Part 4: Collecting Data about spring and neap tides and Moon phases

Do some brief independent research to learn about spring tides and neap tides. In your research, find a video or animation that shows the positions of the Earth, Sun and Moon.

20. View the diagram below and compare it to the animation. Select the **two** positions for the Moon when there are spring tides.

- ☐ Position A
- ☐ Position B
- ☐ Position C
- ☐ Position D



21. What type of tide would you see if the Moon was at Position D and why?

- ☐ Neap tide because the Moon is perpendicular to the Sun and Earth giving a quarter moon.
- ☐ Neap tide because the Moon is aligned with and on the opposite side of the Earth as the Sun giving a full moon.
- ☐ Spring tide because the Moon is aligned with and on the opposite side of the Earth as the Sun giving a full moon.
- ☐ Spring tide because the Moon is aligned with and on the same side of the Earth as the Sun, giving a new moon.

? How is the tidal range in Eastport, ME related to the Moon's alignment with the Earth and Sun?

Consider the scientific question above about the relationship of the Moon-Earth-Sun alignment and the range of the related tides. You will collect data to answer this question.

To collect these data, the first step is to choose a time period and determine the different Moon-Earth-Sun alignments, which you can see by looking at the Moon phases. A fellow student has done this for you and created a table below for you to write your data in as you collect it.

22. What part of the **process of science** did the fellow student do when creating the table?

- ☐ Ask a scientific question
- ☐ Determine the methods to use
- ☐ Make observations and collect data
- ☐ Analyze data and develop conclusions
- ☐ Share results and conclusions

Go to [NOAA Tides and Currents](#) and choose the Eastport, ME (8410140) station. Go to the Tides/Water Levels tab, and click "Water Levels." Select the dates from September 21, 2025 to September 21, 2025, for one day of data. Click the blue "Plot" button to see the water levels over that day. Determine the tidal range by finding the difference between the first verified high and low tide. In this case, 19.53 ft minus -0.06 ft equals 19.59 ft. Record your data in Data Table 3 for all the dates.

Data Table 3

Date and alignment (phase)	Range (feet)	Date and alignment (phase)	Range (feet)	Date and alignment (phase)	Range (feet)	Date and alignment (phase)	Range (feet)
Sept 21 Aligned (New)	19.59	Oct 6 Aligned (Full)		Oct 21 Aligned (New)		Nov 5 Aligned (Full)	
Sept 29 Perpendicular (Quarter)		Oct 13 Perpendicular (Quarter)		Oct 29 Perpendicular (Quarter)		Nov 11 Perpendicular (Quarter)	

To answer the scientific question, figure out what numbers in Data Table 3 you want to average together. Calculate the **average**, and add it to the table. You will need to extend the table.

23. What numbers did you use to calculate the **average**?

- ☐ I calculated the average for all the tidal ranges because this averages the largest number of ranges for more accurate results.
- ☐ I calculated the average for each row because this averages together the tidal ranges for the same Moon-Earth-Sun alignment.
- ☐ I calculated the average for each column because this averages together the tidal ranges for similar dates in each month.

24. What is the **average** you calculated for the average that includes the data for September 21, 2025?
_____ ft

25. What part of the **process of science** did you do when filling out the table?

- ☐ Ask a scientific question
- ☐ Analyze data and develop conclusions
- ☐ Determine the methods to use
- ☐ Share results and conclusions
- ☐ Make observations and collect data

26. Based on the data in the table, select the evidence-based conclusion that answers the question regarding how the tidal range is related to the Moon-Earth-Sun alignment.

- ☐ The tidal range is highest when the Moon, Earth, and Sun are aligned during the new and full moon phase (20 feet), and lowest when the Moon, Earth, and Sun are perpendicular to each other during the quarter moon phase (14 feet).
- ☐ The tidal range increases as the date becomes later, from 15 feet in September to 20 feet in November. The Moon, Earth, and Sun alignment ranges from perpendicular to each other during the quarter moon phase to aligned during the new and full moon phase.
- ☐ The tidal range averages 17 feet., with a maximum of 23 feet when the Moon, Earth, and Sun are perpendicular to each other during the quarter moon phase to a minimum of 12 feet when the Moon, Earth, and Sun are aligned during a full moon.
- ☐ The numbers I got for the average tidal range were an alternating pattern: 15 ft, 19 ft, 15 ft and 19 ft.

Earlier in the lab, you determined that tides usually occur twice each day because of Earth's rotation in 24 hours, and the Moon's orbit around the Earth adds 50 minutes. Spring and neap tides have a different cause.

27. Think about **causation versus correlation**. What is the correct causation relationship related to spring and neap tides?

- ☐ The orbit of the Moon around the Earth causes two spring tides and two neap tides each month.
- ☐ The higher range of the tides each month causes the spring tides, while the lower range of the tides each month causes neap tides.
- ☐ The spring tides that happen two times a month cause the neap tides that happen at opposite times in the month.
- ☐ There is no causation relationship. Spring and neap tides correlate with the position of the Moon.

Part 5: Planning methods to answer a scientific question

 **Is the tidal range affected by the latitude?**

You are asked the above scientific question about tides and latitude, which is the distance from the equator. What methods would you use to collect data to answer the scientific question?

Here are the steps (out of order) to answer the scientific question. Put the steps in order (Step 1, Step 2, etc.). One step will not be used.

- Create a table to record the data, with 6 rows (for each station) and the columns labeled “4 highest tides” and “4 lowest tides.” And a final column labeled “Tidal Range.”
- Find 6 tidal stations that are at different latitudes from the equator. Decide to collect data for the same day for each station.
- Go to the Time and Date website to determine the phase of the Moon for each high tide.
- Use the NOAA Tides and Currents website to collect the data for each station, recording each measurement and calculating the range and the average.
- Compare the averages for each latitude to see if there’s a relationship.

28. What is Step 1?

29. What is Step 2?

30. What is Step 3?

31. What is Step 4?

32. Select **two** ways that these methods could be improved.

- ☐ Add a fourth column and label it “Time between high tides.”
- ☐ Select 6 tidal stations around the Earth at the equator.
- ☐ Find more than one station at each latitude.
- ☐ Take measurements for 10 days at each station.
- ☐ Add a row to record the Moon phase.

Part 6: Determining how to answer scientific questions

Below are scientific questions (Questions A-E) to answer questions in Part 6.

- **Question A. “For stations within bays, how does their distance from the ocean affect the accuracy of the tide predictions?”**
- **Question B. “Do semidiurnal tides occur at the same time each day?”**
- **Question C. “When is low tide next Saturday morning so I can collect seashells?”**
- **Question D. “How much can tides influence the severity of flooding during a hurricane?”**
- **Question E. “How do tides affect people living within 20 feet of the shore in Daytona Beach, Florida?”**

33. Which of the scientific questions (Questions A-E above) would NOT be answerable with [NOAA Tides and Currents](#)?

- ☐ Question A ☐ Question B ☐ Question C ☐ Question D ☐ Question E

Read the following Methods Section that describes the plan to answer a scientific question:

- 1) Identify two tide stations in five different bays.
- 2) Create a table. The headers of the columns are “far within a bay” and “near the ocean shore.” The rows are for each bay.
- 3) Collect data on [NOAA Tides and Currents](#) by writing down the difference between the predicted and actual water level for each station.
- 4) Fill in the table with the data and compare averages for the two locations.

34. Which of the scientific questions (A-E, above) is answerable using these methods?

- ☐ Question A ☐ Question B ☐ Question C ☐ Question D ☐ Question E

Read Data Table 4:

Data Table 4

Date	Time of first high tide	Time of second high tide

35. Which of the scientific questions (A-E, above) needs a table like Data Table 4?

- ☐ Question A ☐ Question B ☐ Question C ☐ Question D ☐ Question E

Part 7: Synthesizing the process of science

❓ How does the distance between the Sun and Earth affect the tidal range?

You are asked to write a research report answering the scientific question above about the distance to the Sun. You decide to focus on dates for the spring tides during the new moon around July 2, when the Earth is farthest from Sun, and January 2, when the Earth is closest to Sun.

Here is the **first sentence** of your report:

To determine how the distance between the Sun and Earth affects the tidal range, I measured the tides for Santa Barbara, CA (station 9411340) during the new moon on June 28 and January 2.

36. Which sentence is a good **second sentence for your report?**

- ☐ I collected data using NOAA's Tides and Currents website, with the location in Santa Barbara, and I analyzed it to calculate the tidal range.
- ☐ I made a table for tidal range in Santa Barbara with two columns, one labeled "Spring tide on June 28" and one labeled "Spring tide on January 2."
- ☐ I planned my data collection by making a table with a row for Santa Barbara and columns for spring and neap tide dates.
- ☐ The tide station in Santa Barbara is between Los Angeles and San Francisco which will give better data than a station near a large city.

37. Which sentence is a good **third sentence for your report?**

- ☐ To collect data for the table, I used NOAA's Tides and Currents website and recorded the height of the high tide during spring and neap tides for the determined dates.
- ☐ The Time and Date website had the information I needed to choose the Santa Barbara tide station for data collection.
- ☐ The proximity of the Santa Barbara tide station to the shore was a useful characteristic to give the most accurate data for this project.
- ☐ I found Los Angeles, San Francisco, and Santa Barbara on NOAA's Tides and Currents website, and collected high and low tide data for each location on each date.
- ☐ To collect the data for the table, I used NOAA's Tides and Currents website, setting the location for Santa Barbara and the dates for January 2 and June 28.

38. Which sentence is a good **fourth sentence for your report?**

- ☐ The tidal range for June 28 was 7.2 feet, and the tidal range for January 2 was 9.2 feet.
- ☐ The high tide for June 28 was 6.2 feet, and the high tide for January 2 was 5.4 feet.
- ☐ The average tidal range for June 28 and January 2 was 7.9 feet.
- ☐ The tidal range for Los Angeles, San Francisco, and Santa Barbara averaged together on June 28 was 5.4 feet, and the tidal range for January 2 was 6.2 feet.
- ☐ The high tide and low tide for both dates was about 5 feet.

39. Which sentence is a good **final sentence for your report?**

- ☐ I conclude that during a spring tide, the tidal range when the Earth is closer to the Sun is the same as the tidal range when the Earth is farther from the Sun.
- ☐ I conclude that during a spring tide, the tidal range when the Earth is closer to the Sun is higher than the tidal range when Earth is farther from the Sun.
- ☐ I conclude that during a spring tide, the tidal range when the Earth is closer to the Sun is lower than the tidal range when the Earth is farther from the Sun.

40. You ask someone to peer review your report. What is one suggestion they might have to help you improve your study?

- ☐ Select a tide station near a river inside a bay to give more detailed data than one on the coast.
- ☐ Add two more tide stations in case the station you selected is unusual.
- ☐ Compare the tides exactly on January 2 and July 2 and ignore the phase of the moon.
- ☐ Calculate the average of the tides on full moons around January 2, April 2, July 2, and October 2.
- ☐ Analyze the data by averaging the high and low tide together on June 28 and July 2.

41. What part of the **process of science** did the peer reviewer think you should improve?

- ☐ Ask a scientific question
- ☐ Determine the methods to use
- ☐ Make observations and collect data
- ☐ Analyze data and develop conclusions
- ☐ Share results and conclusions

Reflection

42. Which question in this lab connects to your personal experience? Consider the lab topic, math skills, and the process of science. You may also consider your lived experience or stories you've encountered. To earn credit, list the question number and explain how it relates in 2-3 sentences.