Activity Description & Estimated Class Time

This activity is designed for two 50-minute class periods where students analyze properties of transverse waves. Students manipulate a computer wave simulation to develop and demonstrate understanding of cycle, period, frequency, wavelength, and amplitude.

Correlations to NC Science Standards

PS.6.3.1 Use models of a simple wave to explain wave properties in seismic, light, and sound waves that include: waves having a repeating pattern with a specific amplitude, frequency, and wavelength, and the amplitude of a wave is related to the energy of the wave.

Learning Targets

Students will demonstrate knowledge and understanding of the following concepts:

- wavelength
- amplitude of waves

Brief Science Background

As a wave travels, it cycles between a high (peak) and low (trough) value. The distance from peaks and troughs to the zero line is called amplitude. The wave completes a cycle in a specific amount of time, called the period, and the cycles occur at a set rate. The rate of cycling is called frequency. When waves move through a medium at a constant speed and cycle at a constant rate, the distance between peaks (or troughs) is constant. That distance is called wavelength.

Transverse Waves

Materials

Materials for the whole class

- access to computers, 1 per pair of students
- the ability to project Challenges (SD 1)
- Wave Components descriptions (SD 2), either one copy for projection or as one copy per pair of students
- Wave Simulator Student Activity Sheet (SD 3); one per student
- Transverse Waves Exploration Student Activity Sheet (SD 4); one per student

Materials for groups of 2 students

- a computer connected to the internet
- Wave Components descriptions (SD 2), if this will not be projected for the whole class
- 2 Wave Simulator Student Activity Sheets (SD 3)
- 2 Transverse Wave Exploration Student Activity Sheets (SD 4)

Procedure

1. Hand out materials to pairs of students.
2. Post the website https://ciblearning.org/wave/wave-on-a-string/wave-on-a-string_en.html and ask students to go to the website. This will allow students to use the wave simulation.
3. Project Challenges (SD 1). Ask everyone to try out features of the simulation. Challenge them to find and list 13 things that they can change or do with the simulation. Let them know that everyone will share what they find out after 5

Procedure cont.

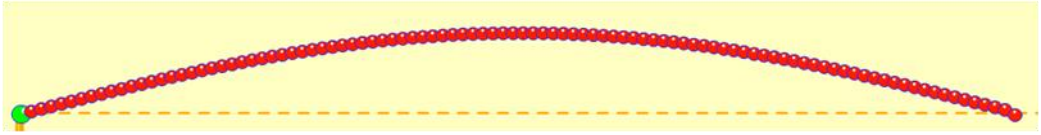
minutes. When 5 minutes have elapsed, list the things students tell you they discovered. Afterwards, show the complete list found in SD 1:

- change the frequency setting
- change the amplitude setting
- move the vertical ruler
- move the horizontal ruler
- move the reference line
- pause (stop the moving wave)
- play (make the wave move)
- step along the path the wave makes
- move the timer
- start and stop the timer
- step-time wave motion
- reset the wave motion
- reset the timer

4. Allow a few minutes for students to learn how to do things on the list that they did not discover themselves. Let students who figured out things teach those who did not. Do not be concerned if students do not figure out how to step-time wave motion. They will get directions for this later on.

5. Ask students to manipulate the simulator to make a wave that looks like a wave they made with the spring. Ask which type it is. Ask the class to share things they notice about the computer-generated wave.
   The wave is transverse. Students might notice:
   - it seems to travel from left to right
   - it goes up and down with a dotted line in the middle
   - it can go faster or slower
   - it can be taller or shorter
   - it makes a pattern in which the wave shape repeats

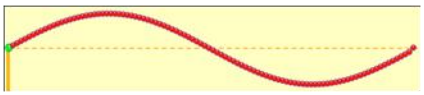
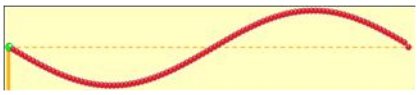
6. Project SD 1 Challenge 2. Ask students to use their simulators to make a wave in which both ends touch the dotted yellow line and no ball is completely below the line. The amplitude setting must be between 20-100. Remind them to use the pause and step functions to put both ends of the wave on the line. Do not otherwise direct them. Ask them to pause the wave once they have it. Circulate to check. To show them what it should look like, project Figure 1 from SD 1:



   Ask students to call out or report first the amplitude and then the frequency reading that accomplish this. Waves should look like the diagram above. Ask students if they notice any pattern in the readings.
   Look for frequency settings around 5. frequency settings are all similar but amplitude settings can be anything above 20.

7. Project SD 1 Challenge 3. Ask students to set the amplitude between 20 and 100 and then make the waves shown:

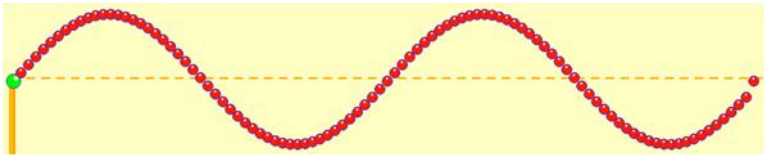
Procedure cont.

 and 

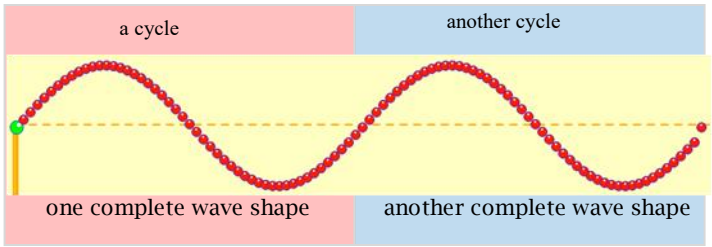
Students will need to use the pause and step functions to put both ends of the wave on the yellow dotted line. Ask students:

- to call out or report their amplitude and frequency readings.
  Look for frequency settings around 10.
- to find the shape of the wave from Challenge 2 (step 6) within the new wave they just generated in this step (Challenge 3).
  The shape from Challenge 2 is the first half of the Challenge 3 wave shown in the left-hand figure above, and it is also the second half of the Challenge 3 wave shown in the right-hand figure above.
- "What is the relationship between the frequency setting of the first (Challenge 2) wave and this new (Challenge 3) wave?
  The new wave has a frequency setting that is twice that of the old wave.

8. Ask students to describe what they notice about this wave.
   They might say some of the following:
   - It has one dip and one high spot.
   - It touches the dotted line in three places.
   - The bottom is the same as the top, only upside down and moved to the right.
9. Introduce the terms **crest** and **trough**. Tell students that the crest is the high point of a wave. A trough is a low point of a wave. Point these out on the screen.
10. Ask the class for ideas about how the waves generated by the computer change as the frequency setting is increased but the amplitude is kept the same. (They've just seen that increasing the frequency caused more wave parts to be shown on the screen.) Project SD 1 Challenge 4 and ask students to draw their predictions. Then let them change the frequency to 20, run and pause. The wave should look like SD 1 Figure 2:



11. Ask students what they notice about this wave. Accept all responses. If students do not notice that the wave form repeats twice, point it out. You can highlight half of this wave as in SD 1 Figure 3:



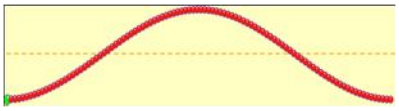
12. Introduce the term **cycle**. A wave cycle is one complete wave shape. There are two complete cycles in Figure 3. Ask students to respond on SD 3 to the prompt: **Without using the words "complete wave shape," write your own definition of a wave cycle so that someone else could identify a cycle when they see one.**

Procedure cont.

Allow students to use the wave simulator to check and revise definitions as needed. Point out that this example of a cycle starts on the dotted yellow line, but a cycle can start anywhere on a wave.

13. Project SD 1 Figure 1 again. Ask students what part, or fraction, of a cycle this figure represents.
    This figure represents 1/2 cycle.

14. Project SD 1 Figure 4. Ask students if these waves represent one full cycle, and why they do or do not.
    Both of them do represent full cycles because they each end at the same place where they began, in relation to the yellow-dotted center line, and they also form only one wave shape.
    Figure 4:



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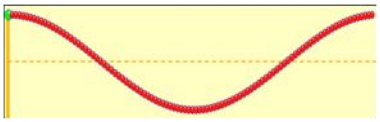
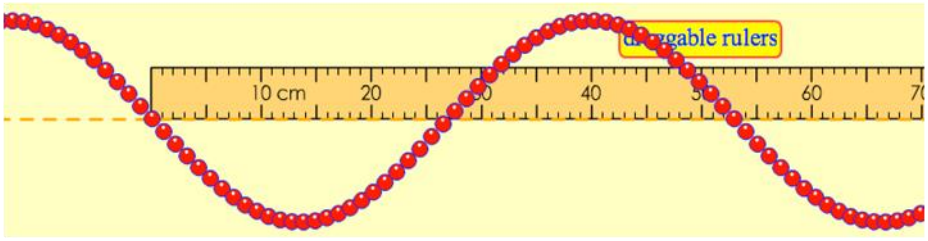


15. As a check, ask students to set their frequency controls to 30, 40, and 50, and at each setting ask them to report how many crests and how many troughs are showing. Then ask them how many cycles are showing at each frequency setting.
    There are 3, 4, and 5 crests and troughs, respectively, and 3, 4, and 5 cycles.

16. Project SD 1 Challenge 5. Ask students for their ideas about how they could measure the length of one whole cycle. In particular, ask them where they think the measurement should start and end. They might suggest starting from the dotted reference line, or measuring from crest to crest as shown below, but other ways also work. After individual students or pairs of students have chosen a way to measure one cycle and recorded their measurements, ask them to measure again using a different starting point. Ask if they got the same result.
    The two measurements should be identical. For a frequency setting of 20, look for measurements near 53 cm.



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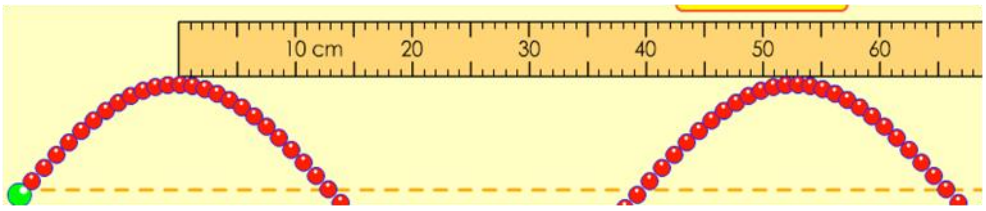
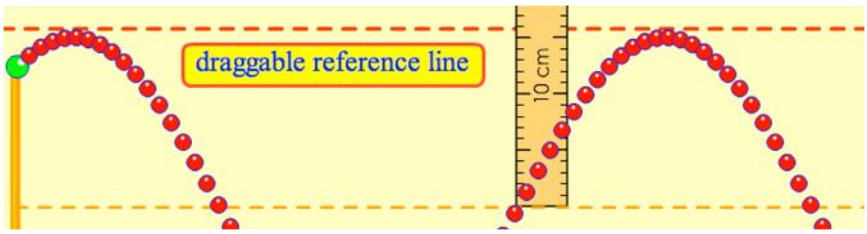


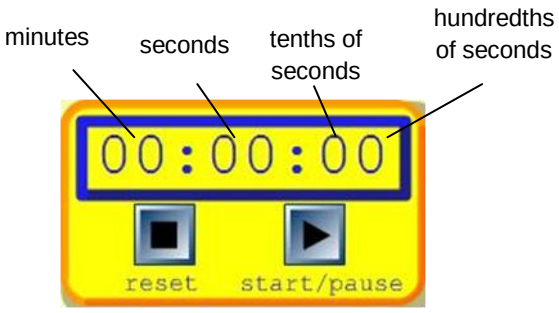
Procedure cont.

17. Introduce the term wavelength: the length of a wave's complete shape, for example:
    - from crest to adjacent crest or trough to adjacent trough
    - from where it crosses the yellow-dotted center line heading downward, to where it crosses the center line going downward again

    Interesting wave fact: the waves produced by microwave ovens are about one foot long
18. Project SD 1 Challenge 6. Ask students to set the amplitude to 80, run a wave and pause it. Then ask them to use the draggable vertical ruler to measure the height in centimeters from the dotted center line to a crest. Discuss reasons for using these measurement points. Point out the draggable reference line as a tool. There are many ways to do this. Most students can find their own way or learn from others. A student might measure the height of crests by setting the reference line to touch the tops of the highest balls and setting the vertical ruler to measure the distance between the dotted center line and the reference line, as pictured below. Look for measurements just under 16 cm.



19. Introduce the term **amplitude**. Explain that amplitude is the distance from the center point of a wave to the highest or lowest point of a wave. It is NOT measured from lowest to highest points.
20. Point out that so far, the class has measured lengths and heights of waves. It is also important to know how fast a transverse wave moves up and down (or side to side). Ask students what additional tool or tools they would need to measure how quickly a wave rises and falls.
    You need a timer to measure how fast something happens.
21. Project SD 1 Challenge 7. Ask students to time one cycle of a wave. Explain how to use the timer in the wave simulator.



Procedure cont.

22. Give these instructions:
    1. set the frequency to 30
    2. use the step function and any location you choose to set the wave in a position where you can know when you have finished a whole cycle
    3. when you are ready to measure, reset the timer to 0
    4. use the step button to step through exactly one cycle of a wave
    5. record the time it took for a whole cycle on SD 3

    Look for times around 0.91 seconds.

23. Introduce the term **period**. Students have just now measured the period of a wave: the time it takes for a wave's shape to repeat, for example, from a crest to the next crest. Also introduce the related term **frequency**. Frequency is the number of cycles of a wave that occur in a given amount of time. It is also the number of periods in a second. Frequency is often given as the number of cycles per second.

    Interesting fact: FM radio towers send out waves that have a period of about one 100 millionth of a second. That's a pretty short time. By the time a second has gone by, that wave has made 100 million cycles.

24. Project SD 1 Wave Components list and leave it up. Give out Transverse Wave Exploration student activity sheet (SD 4). Students should complete these worksheets individually but work in pairs at computers to collect the data needed. Ask them to complete only through Step 5, stop, and minimize the simulation window. Step 6 of the worksheet asks students to predict what doubling the frequency will do to the time of the period. Make sure students record their predictions on their worksheets before they use the simulation to test their predictions and record their results.

SD 1
pg. 1 of 4

Challenges

Challenge 1 - Try out features of the simulation. Find and list 13 things that you can change or do with the simulation. Everyone will share what they find out after 5 minutes.

Things You Can Do With the Wave Simulator

- change the frequency setting
- change the amplitude setting
- move the vertical ruler
- move the horizontal ruler
- move the draggable reference line
- pause (stop the moving wave)
- play (make the wave move)
- step along the path the wave makes
- move the timer
- start and stop the timer
- time between steps
- reset the wave motion
- reset the timer

SD 1
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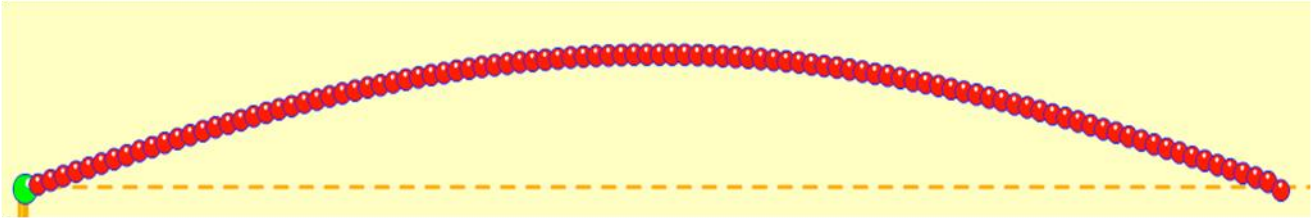
Challenges

Challenge 2 - Use the wave simulator to make a wave in which:

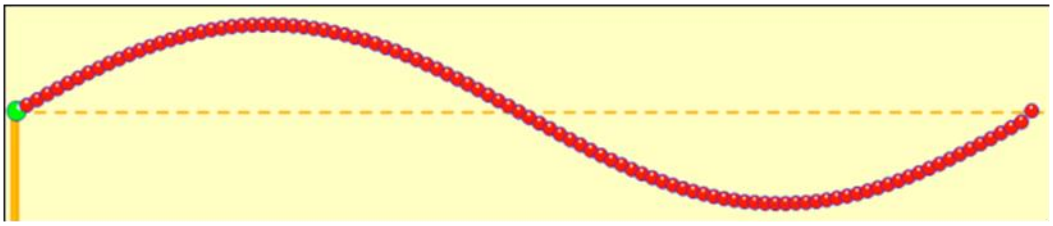
- **both ends touch the dotted yellow line**
- **no ball is completely below the line**
- **the amplitude setting is between 20 and 100**

TIP: Use the step function to get the green ball on the far left of the dotted yellow line and a red ball on the far right of the dotted yellow line.



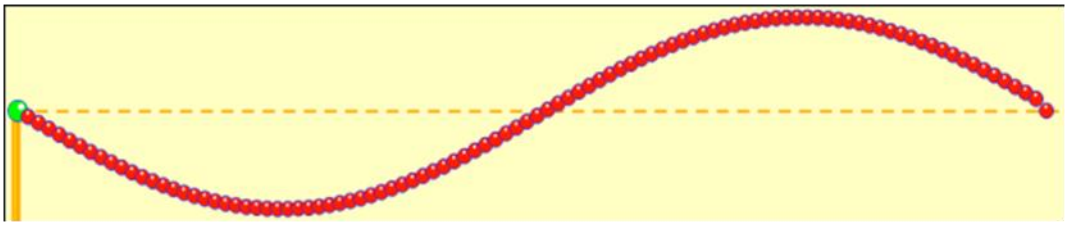
Challenge 3

1. Make a wave that looks like this:



2. Record your amplitude and frequency settings

3. Make a wave that looks like this:



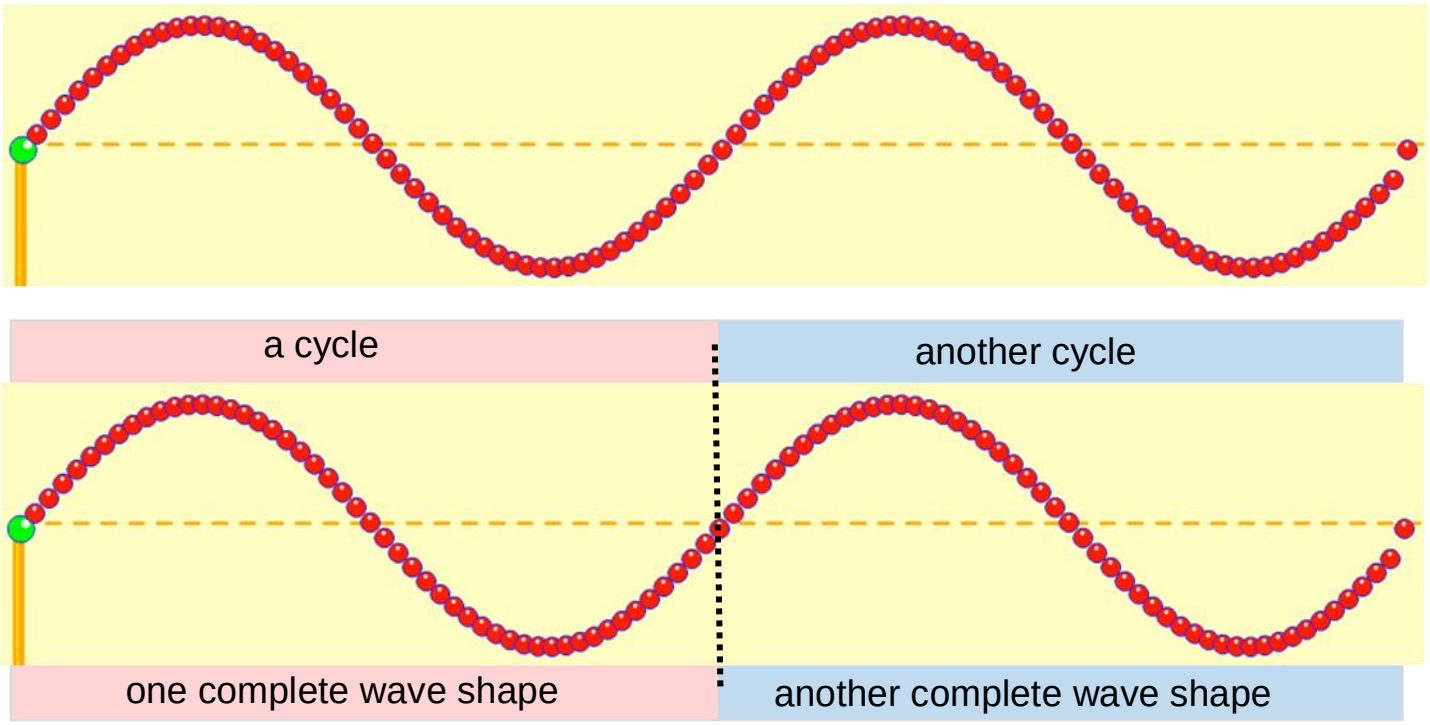
4. Record your amplitude and frequency settings

SD 1
pg. 3 of 4

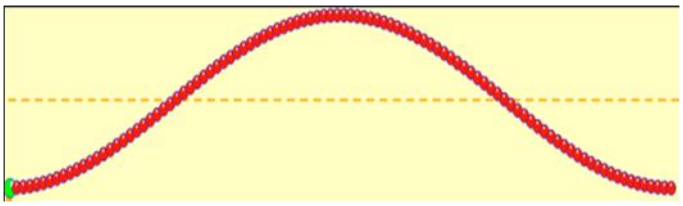
Challenges

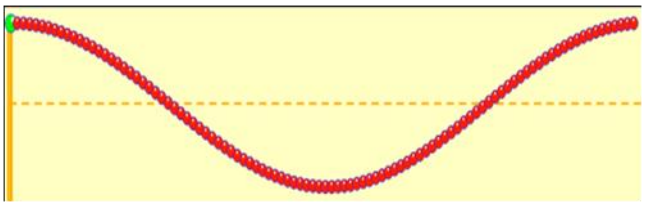
Challenge 4

1. Without using the computer to look at a wave, draw a wave that would be made by setting the frequency to 20.
2. After you have drawn your prediction, set the frequency at 20, run and pause. Compare the wave to your prediction.



Challenge 5 – Using a frequency setting of 20, measure the length of one whole cycle.





SD 1
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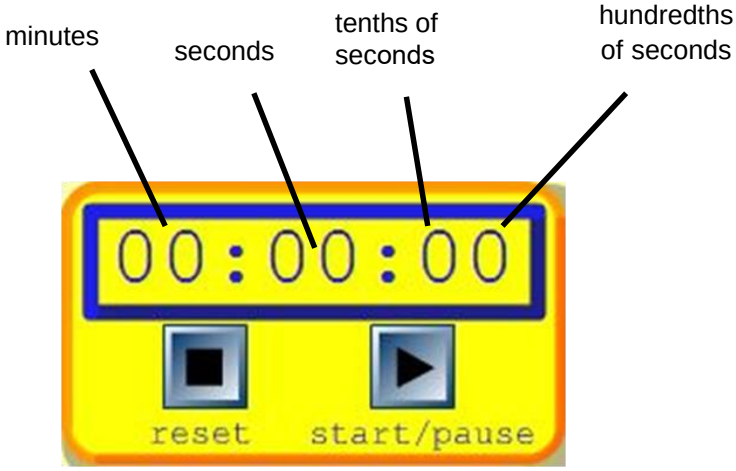
Challenges

Challenge 6

1. Set the amplitude to 80, run a wave, and pause it.
2. Measure the height in centimeters of a crest, measuring from the dotted center line.



Challenge 7 - Time one cycle of a wave.

1. Set the frequency to 30.
2. Use the step function and any marker you choose to stop the wave in a position where you can know when you finish a whole cycle
3. When you are ready to measure, reset the timer to 0
4. Use the step function to step through one cycle
5. Record the time it took for a whole cycle in your notebook.

SD 2

Wave Components

Crest: the crest is the highest point of the wave. The trough is the lowest point of the wave.

Wavelength: wavelength is the distance over which a wave's shape repeats, for example, from crest to the adjacent crest or from trough to adjacent trough.

Amplitude: amplitude is the distance from the center point of the wave (also called rest point) to the highest or lowest point. It is how high and how low a transverse wave goes.

Cycle: a cycle is one complete shape of a wave. For example, a cycle may be measured from crest to crest or trough to trough.

Period: the period is the time it takes for a wave's shape to repeat, for example, from crest to adjacent crest or trough to adjacent trough.

Frequency: the frequency is the number of cycles of a wave that occur in a given amount of time. Frequency is often stated as the number of cycles per second.

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Wave Simulator Student Activity Sheet

Name:

1. Go to https://ciblearning.org/wave/wave-on-a-string/wave-on-a-string_en.html

Challenge 1

1. Find and list 13 things that you can change or do with the simulation.

Challenge 2

1. Use the wave simulator to make a wave in which:
   - Both ends touch the dotted yellow line
   - No ball is completely below the line
   - The amplitude setting is between 20 and 100

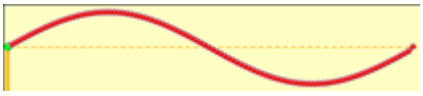
   TIP: Use the step function to get the green ball on the far left of the dotted yellow line and a red ball on the far right of the dotted yellow line.

2. Record your amplitude and frequency.

Amplitude	Frequency

Challenge 3

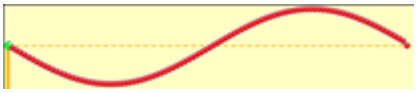
1. Make a wave that looks like this:



2. Record your amplitude and frequency.

Amplitude	Frequency

3. Make a wave that looks like this:



Wave Simulator Student Activity Sheet

4. Record your amplitude and frequency.

Amplitude	Frequency

5. What is the relationship between the frequency setting of the first wave **(Challenge 2)** and the new waves **(Challenge 3)**? _____

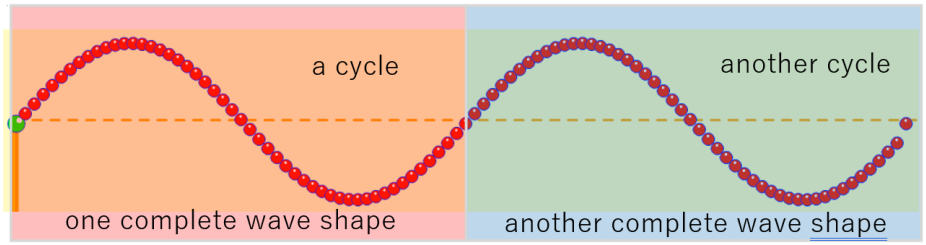
6. What do you notice about this wave? _____

Challenge 4

1. The **crest** is the high point of a wave. A **trough** is a low point of a wave. Without using the computer to look at the wave, draw a wave that would be made by setting the frequency to 20.

2. Set the frequency at 20, run, and pause. Compare the wave to your prediction. What do you notice about the wave? _____

3. A **wave cycle** is one complete wave shape. There are two complete cycles in the wave from **Challenge 4**. Without using the words "complete wave shape," write your own definition of a wave cycle so that someone else could identify a cycle when they see one. You may use the wave simulator to check and revise your definition as needed. Your cycle above starts on the dotted yellow line, but a cycle can start anywhere on a wave.



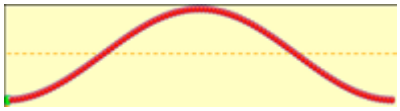
_____

_____

4. What part, or fraction, of a cycle does this figure represent? _____

This figure represents ½ of a cycle.

5. Explain if these waves represent one full cycle.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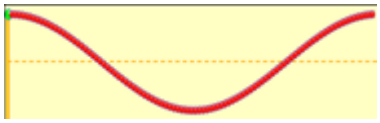


_____

_____

Wave Simulator Student Activity Sheet

6. Set your frequency controls to 30, 40, and 50. At each setting report how many crests and troughs are showing and how many cycles are showing.

Frequency	# of Crests and Troughs	# of Cycles
30		
40		
50		

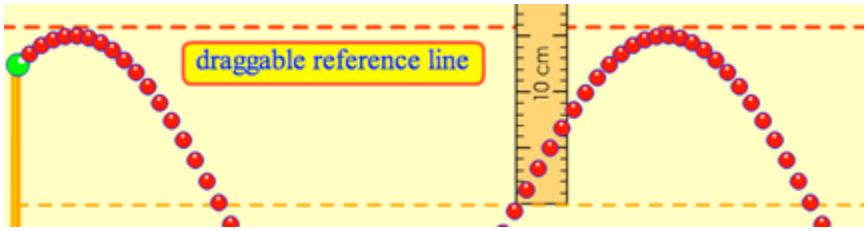
Challenge 5

1. How could you measure the length of one whole cycle? _____
2. After you have chosen a way to measure one cycle, measure and record one whole cycle.
3. Use a different starting point and measure one cycle again. Did you get the same result? _____
4. Using a frequency setting of 20, measure and record the length of one whole cycle. _____

Wavelength is the length of a wave's complete shape.

Challenge 6

1. Set the amplitude to 80, run a wave, and pause it.
2. Measure the height in centimeters of a crest, measuring from the dotted centerline. You may use the reference line as a tool. Height = _____

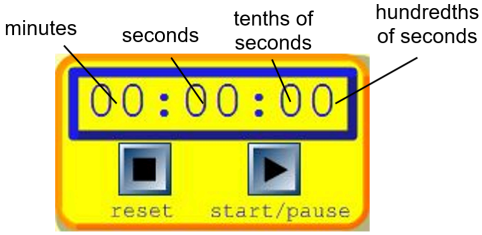


Amplitude is the distance from the center point of a wave to the highest or lowest point of a wave. It is **NOT** measured from lowest to highest points.

3. So far you have measured the lengths and heights of waves. It is also important to know how fast a transverse wave moves up and down (or side to side). What additional tool or tools would you need to measure how quickly a wave rises and falls? _____

Challenge 7

1. You will use the timer in the wave simulator to time one cycle of a wave. The timer looks like this:



2. Set the frequency to 30.

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Wave Simulator Student Activity Sheet

3. Use the step function and any marker you choose to stop the wave in a position where you can know when you finish a whole cycle.
4. When you are ready to measure, reset the time to 0.
5. Use the step function to step through one cycle.
6. Record the time it took for a whole cycle. _____

   You have just now measured the period of a wave. The **period of a wave** is the time it takes for a wave's shape to repeat. **Frequency** is the number of cycles of a wave that occur in a given amount of time. It is also the number of periods in a second. Frequency is often given as the number of cycles per second.

SD 4

Transverse Wave Exploration

1. Set the frequency and amplitude controls at 48 and begin running the wave. Use the pause button to stop the wave. Measure a wavelength. The wavelength measurement is_____.
2. With the wave stopped and the frequency and amplitude still set at 48, measure the amplitude of the wave. The amplitude measurement is_____.

3. Make a wave that has a length of 20 cm. Record the control settings that achieved this length.

   Amplitude _____Frequency _____

   Which of the two controls made the most difference in length?_____

   What difference did the other one make?_____

   What do you think might explain this? _____

   _____

4. Adjust the controls to make a wave measuring 15 cm in wave height..

   Amplitude setting_____ Frequency setting _____

   Which control makes the most difference in wave height?_____

   What difference does the other one make? _____

   What do you think might explain this? _____

   _____

5. Set the frequency to 25 and use the timer to find how long one complete cycle takes. Record the time (to the nearest .01 sec.): _____seconds.

   Describe how you knew when the wave looked exactly like it did when you started: _____

   _____

   With the frequency set to 25, measure the length of a cycle in centimeters. Length of cycle:_____cm.

6. Minimize the window on the screen. Predict the time the wave will take to go through a cycle with the frequency set to 50. Your prediction: _____Describe how you went about predicting this.

   _____

   _____

   Open the window and test your prediction. Compare your prediction to what actually occurred:

   _____

   _____

7. How does the frequency control relate to actual frequency? _____

_____