Standing Wave Maker

Purpose:
To find patterns associated with the vibrational frequencies that result in standing waves being formed within a rope.

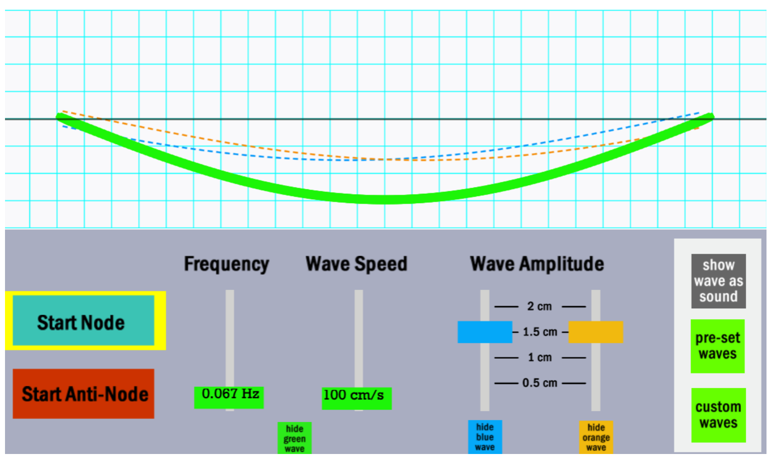
Getting Ready:
Navigate to the **Standing Wave Maker** Interactive at The Physics Classroom website:

https://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Standing-Wave-Patterns

Navigational Path:
www.physicsclassroom.com ==> Physics Interactives ==> Waves and Sound ==> Standing Wave Maker

Getting Acquainted:
Once you've launched the Interactive and resized it, experiment with the interface. Tap on the **Slow Motion**, **Real Time**, and **Fast Motion** tabs at the top of the interface to observe how to control the tempo of the animation. Change the sliders for controlling the **Frequency**, **Wave Speed**, and **Wave Amplitude**; observe their effect upon the wave pattern.

Part 1: Standing Wave Formation
Tap on **Start Node** and **Custom Wave** and **Real Time** tempo. Adjust the **Frequency**, **Wave Speed**, and **Wave Amplitude** values of 0.067 Hz (approximately), 100 cm/s, and 1.5 cm respectively.



1. In Physics, a **standing wave pattern** is established in a rope when there are points in the rope that appear to be standing still. These points of no displacement are referred to as **nodes**. At a frequency of **0.067 Hz** (pictured above), there are two nodes – one on each end. Standing wave patterns also have **antinodes**. These are points that vibrate back and forth between a maximum positive (a high point) and a maximum negative (a low point) displacement. Antinodes are always located midway between two nodes.

   A standing wave pattern is only observed in a rope when it is shook at certain frequencies. Not any old vibrational frequency will cause a standing wave pattern to form … just a set of discrete frequency values can produce the pattern of nodes and antinodes. These frequencies are known as **harmonic frequencies**. The frequency of 0.067 Hz (shown in the diagram) is known as the **first harmonic**; it is the lowest or first frequency for which a standing wave is formed in the rope. Your goal is to determine the set of harmonic frequencies for the rope through which waves travel at 100 cm/s. Gradually increase the frequency until you find the frequency values that cause standing waves with 3, 4, 5, … 10 nodes to form. Make sure the right end of the rope is a node before you record the frequency. Fill in the table below. The last column is a calculated column – the frequency of the n^{th} column divided by the frequency of the 1^{st} column.

Harmonic #	Frequency (Hz)	# of Nodes	# of Antinodes	f_n / f_1
1	0.067	2	1	0.067/0.067 = 1.0
2		3	2	
3		4	3	
4		5	4	
5		6	5	
6		7	6	
7		8	7	
8		9	8	
9		10	9	
10		11	10	

2. Change the speed to any value between 150 cm/s and 200 cm/s (your choice). Record the value: v = ____________ cm/s. Now determine the frequencies which cause standing waves at this speed. Complete the table. Calculate the frequency ratios in the last column (f_1 is the frequency of the 1^{st} row; f_n is the frequency in that particular row.)

Harmonic #	Frequency (Hz)	# of Nodes	# of Antinodes	f_n / f_1
1		2	1	
2		3	2	
3		4	3	
4		5	4	
5		6	5	
6		7	6	

Part 2: Pattern Analysis

3. Observe the values in the last column of each table. For any given row, compare the value of the last column to the values in the other columns. What do you notice? Discuss the patterns you see.

4. As the frequency is increased, in what manner does the wavelength of the standing wave pattern change?

5. Suppose that a rope has a first harmonic frequency of 0.50 Hz. Predict the frequency of the …
   a. … 2nd harmonic: _________ Hz
   b. … 4th harmonic: _________ Hz
   c. … 10th harmonic: _________ Hz
   d. … 128th harmonic: _________ Hz

6. Suppose that a rope has a 3rd harmonic frequency of 2.4 Hz. Predict the frequency of the …
   a. … 1st harmonic: _________ Hz
   b. … 2nd harmonic: _________ Hz
   c. … 6th harmonic: _________ Hz
   d. … 29th harmonic: _________ Hz

7. Suggest an equation that relates the frequency of the nth harmonic (where **n** is an integer) to the frequency of the first harmonic (**f_1**). In your equation, use **f_n** for the frequency of the nth harmonic.