Waves: Simulator Labs

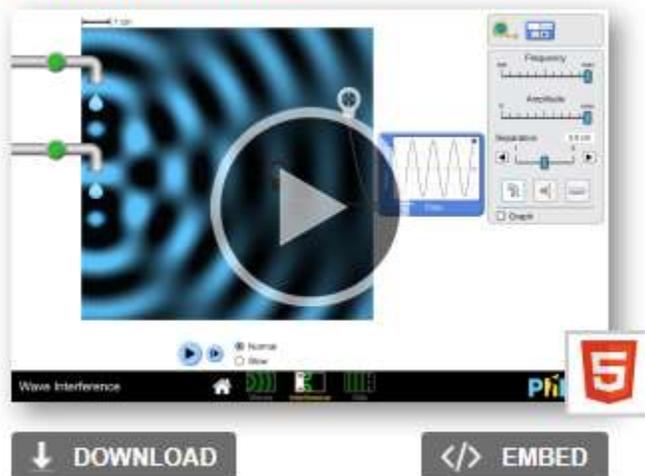https://phet.colorado.edu/en/simulations/category/physics/sound-and-waves

Introduction to the Simulators:

Enter the web address above or follow the link provided in your email (if available). Your screen should look something like this:
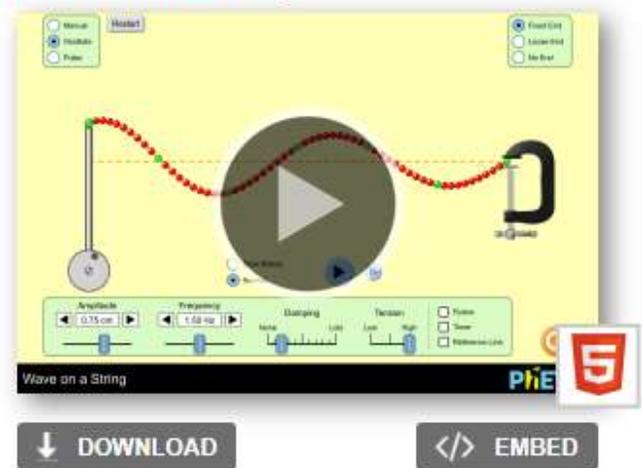

We will be working with the two simulators circled above ("Wave on a String" and "Wave Interference"). When you select a simulator, it will look like the images below. To open the simulator simply click on the image (**do not click** "DOWNLOAD" or "EMBED </>").

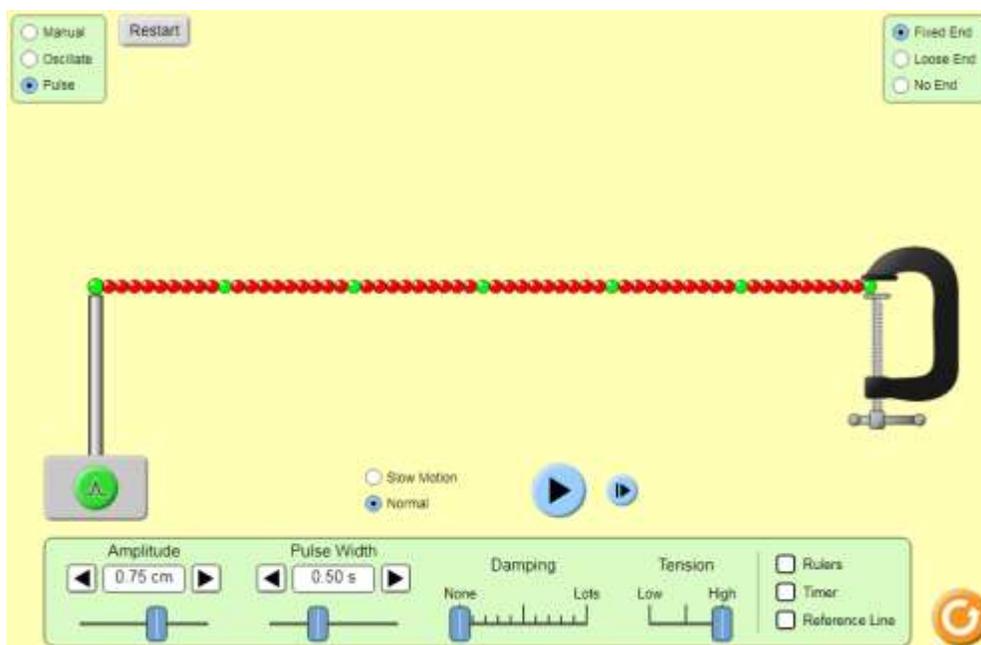I recommend opening both simulators in separate tabs on your browser.

Please spend the next 10-15 minutes playing with the simulators to familiarize yourself with their functions and widgets.

Check the following boxes when you locate the following widgets ("widgets" are interactive tools) and circle the simulator where you found it:

☐ Ruler: "Waves on a String"   or   "Wave Interference"

☐ Time: "Waves on a String"   or   "Wave Interference"

☐ Reference Line: "Waves on a String"   or   "Wave Interference"

☐ Measuring Tape: "Waves on a String"   or   "Wave Interference"

☐ Monitors: Water Level / Pressure / Electromagnetic Field:

                      "Waves on a String"   or   "Wave Interference"
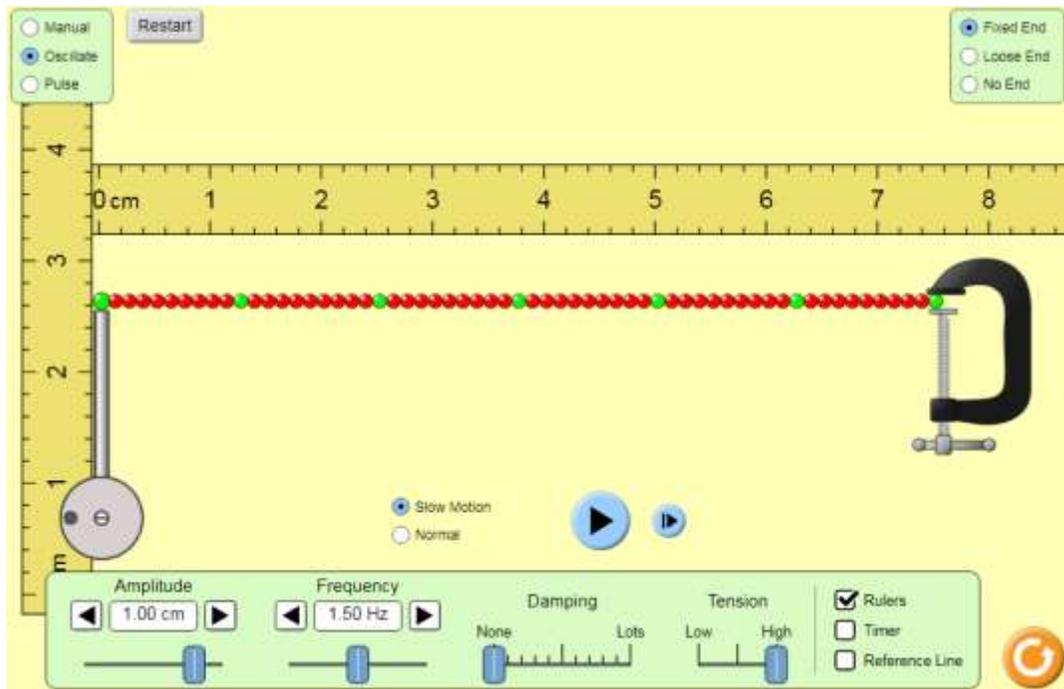

Investigation #1: Waves on a String

Open the "Wave on a String" simulator. Set your dashboard to match the settings below:

1) Press the green button once and carefully observe the propagation of the wave. Now select "Slow Motion," press the Restart button at the top left of your screen, and then click the green button once more to watch the wave again as it first propagates from left-to-right and back again. What path did the reflected wave travel?

2) Press the Restart button on the top left again, and change the setting in the upper right-hand box to say, "Loose End". Carefully observe the propagation of the wave and compare it to what you saw the first time. What changed? (hint: observe the path of the reflected wave)

3) Now try, "No End". What happened to the wave?

4) Reset the simulation to, "Fixed End". Send one pulse down the line, wait a moment, and then send another pulse down the line. What do you observe about the waves' interaction? (It may be helpful to observe the interaction in, "Slow Motion".)

5) Now stop the simulator by pressing "Restart." Change the wave generator to "Oscillate," the Amplitude to 1.00cm, the Frequency to 1.5Hz, and the Tension control to High, as seen in the image below.

Activate the oscillator and observe. You may have to pause and/or restart a couple of times to get the hang of it, because you want to take some measurements *before* the reflected wave interferes with the new waves! ("Slow mo" really helps, and the timer automatically adjusts!)

- Use the timer to measure the time it took for the wave to propagate from left-to-right (don't forget your units!): _____
- Pause the simulator and use the ruler to measure the wavelength of the wave. Record it here (don't forget your units!): _____
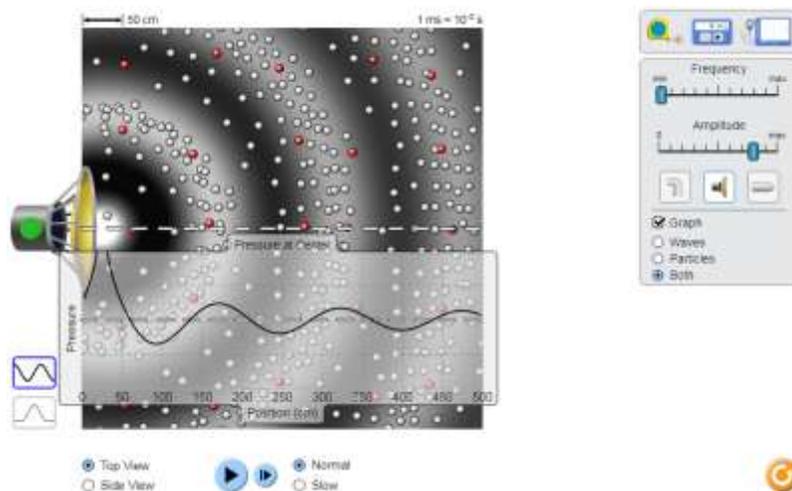
6) Now restart the simulator again and change the Tension setting to Low, keeping all other settings the same. Activate the oscillator and observe.

- Use the timer to measure the time it took for the wave to propagate from left-to-right (don't forget your units!): _____
- Pause the simulator and use the ruler to measure the wavelength of the wave. Record it here (don't forget your units!): _____

7) What do you conclude about the tension of the string, in terms of its effect on the wavelength and on the speed of the wave?

8) Take the final minutes of class to experiment with tweaking different parameters. Which parameter do you feel caused the most interesting behavior in the waves you created, and why?

Investigation #2: Wave Interference

Part A: Open the "Wave Interference" simulator. Click on the option, "Waves." (We will try "Interference" and "Slits" later in the lab.) Your dashboard should now match the settings below:

1) Experiment with the settings and choose the view that you prefer ("Top View" or "Side View".) Try checking the "Graph" box and watch how the plot is related to the amplitude of the wave.

2) Set the frequency to the minimum. Use the timer to measure how long it takes for the wave to travel the length of the box, and record it here (don't forget your units!): _____

3) Set the frequency to the maximum. Use the timer to measure how long it takes for the wave to travel the length of the box, and record it here (don't forget your units!): _____

4) Now switch to observing sound waves (press the speaker icon). Experiment with viewing the wave propagation as Waves, Particles, and Both. Your screen may look something like this:

- Observe the motion of an individual particle (choose a random red dot). What can you say about its motion as the waves pass by?

- What are the particles doing when no sound pulse is traveling through? What makes it realistic?
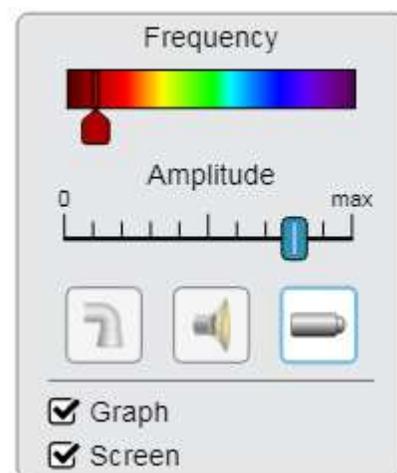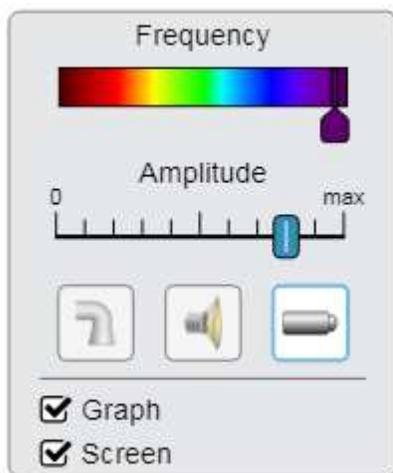

5) Set the frequency to the minimum. Do your best to estimate the wavelength using the measurements on the measuring tape widget, and record it here (don't forget your units!): _____

(Measuring tape widget) ➡️

6) Set the frequency to the maximum. Measure the wavelength and record it here (don't forget your units!): _____

7) Now switch back and forth between Top View and Side View. What do you observe, and why do you think it appears this way?

8) Next, experiment with the laser. What happens to the color when you change the frequency?

9) Use the measuring tape widget to estimate the wavelength of the light waves produced using the following frequency settings (don't forget your units!):
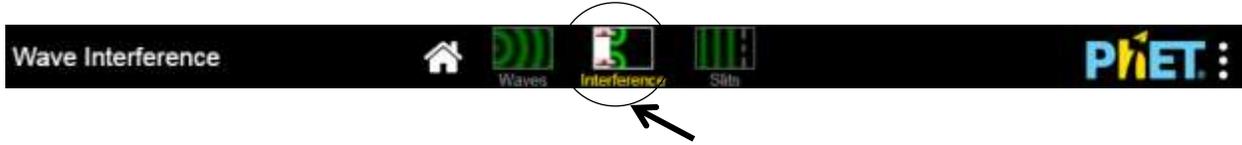
Frequency

Amplitude
0   max

☑ Graph
☑ Screen

Frequency

Amplitude
0   max

☑ Graph
☑ Screen

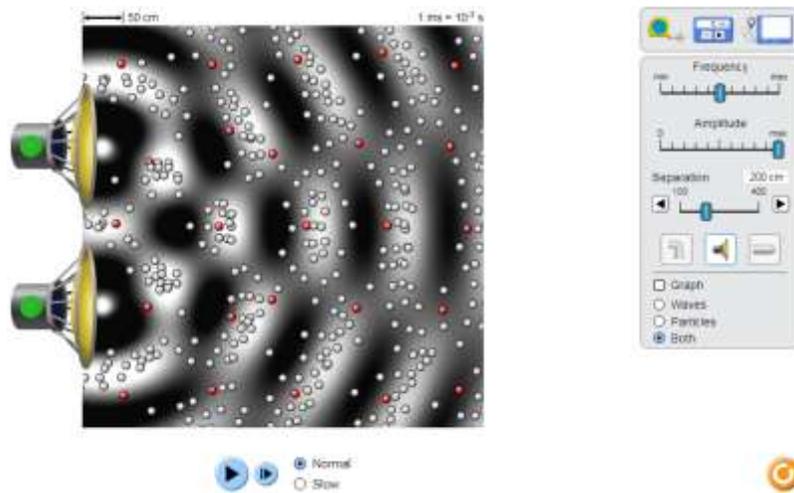Wavelength: _____

Wavelength: _____

10) Now open a new tab in your browser and search for "wavelength of electromagnetic spectrum".

- What is the wavelength range for visible light (units!)? _____ to _____
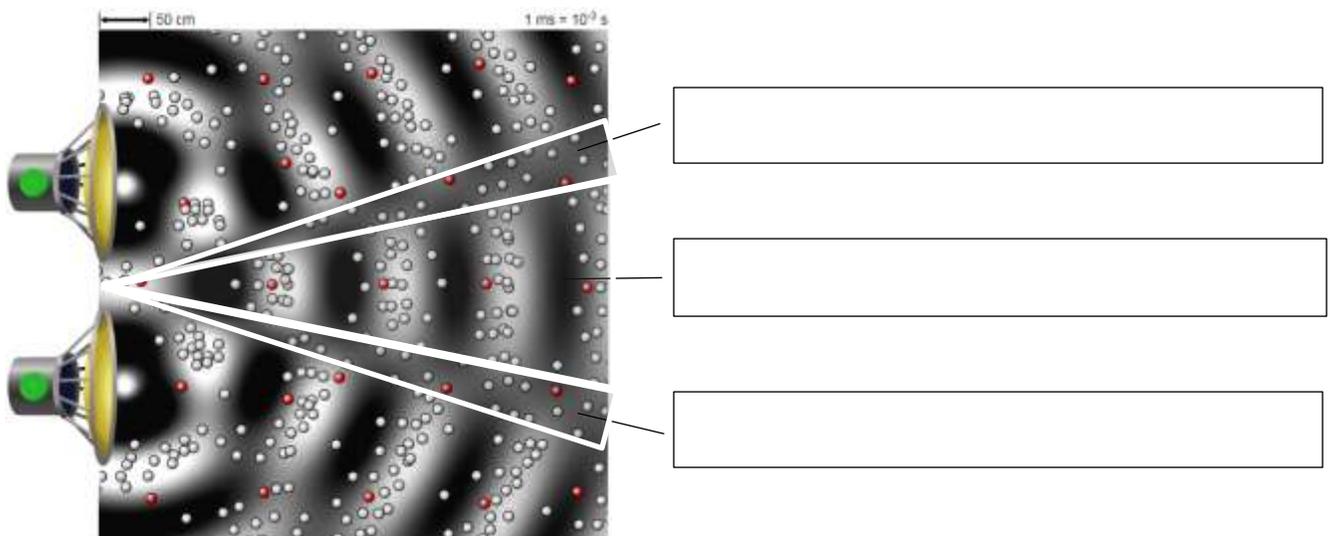- How does this compare to the values you measured in question 9)?

Part B: Select the "Interference" option at the bottom-center part of your screen (see below):

1) Select the Sound option, and set the view to Both (particles and wave). Activate both speakers. Your screen should look something like this:
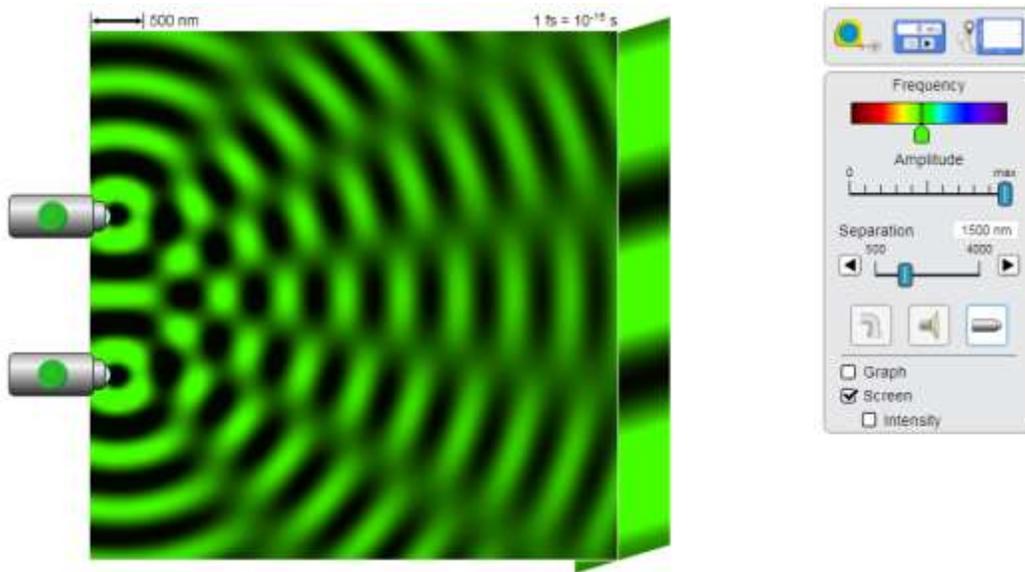

- Label the highlighted areas of destructive interference and constructive interference in the image below. *Please note, the dark patches do NOT indicate the absence of sound!* The dark regions merely represent "troughs" of the waves and the light regions represent the "crests". The spots where the amplitude is zero will be "fuzzy", as they will have an amplitude of zero:
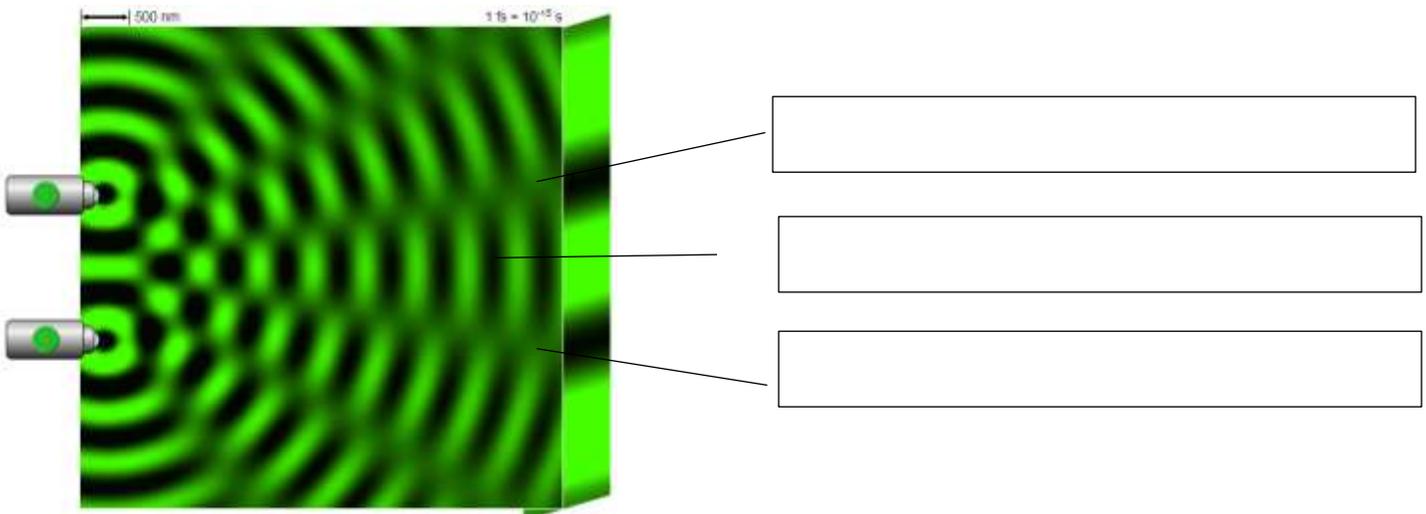
- As you carefully observe the animation, how does the displacement (motion) of the particles in these regions differ?
- Use the pressure probe to view the difference in pressure between the areas of constructive and destructive interference:
  - Pressure in area of destructive interference: _____
  - Pressure in area of constructive interference: _____

2) Select the Laser option, and select the "Screen" option. Your screen should look something like this:
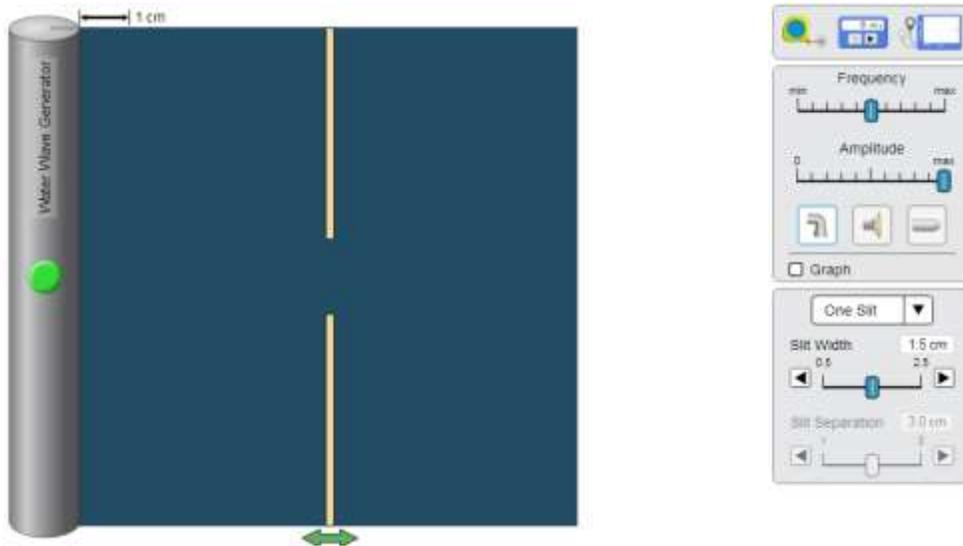

- Identify the regions of constructive interference and destructive interference. Label the areas of destructive interference and constructive interference in the image below. *Please note, the dark patches of the wave do NOT indicate the absence of light!* On the "screen" however, the dark spots *do* represent areas of no light. This shows how the laser light would appear on a screen. (I know, it's confusing. Perhaps black was not the best "trough" color choice…)
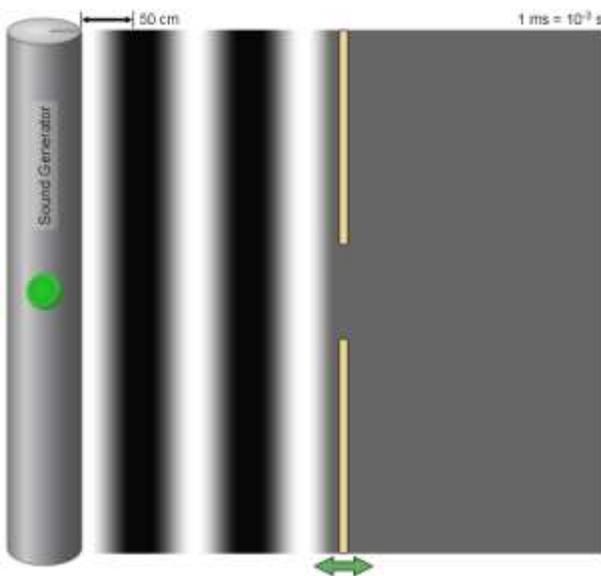
Part C: Select the "Slits" option at the bottom-center part of your screen (see below):
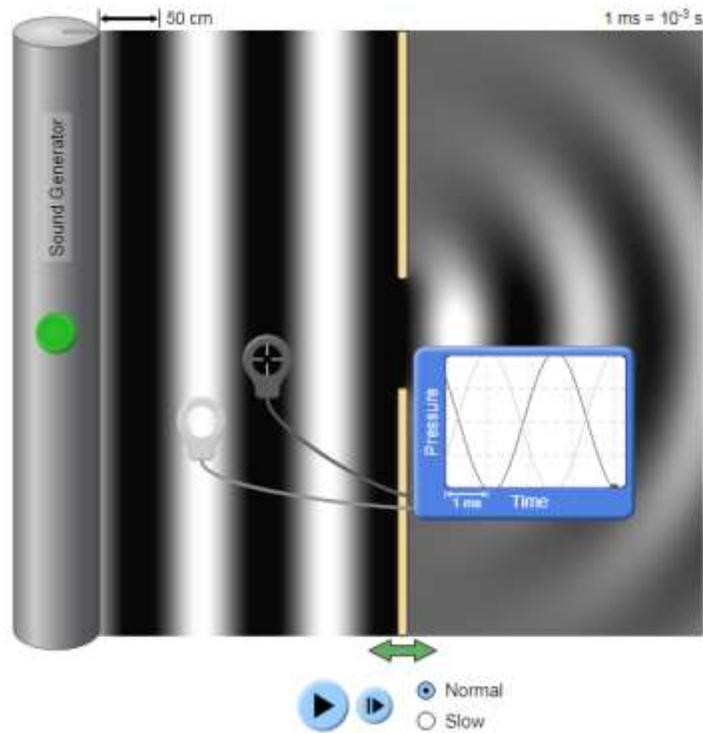

Your screen should look something like this:

1) Switch to sound waves. Activate the sound generator, *but pause it before the first linear wave hits the barrier.*

Predict what will happen when the wave reaches the break in the barrier, using the word, "diffraction":

2) Next, pause the simulator and locate the pressure gauge. Place one lead on a region of a trough (black), and the other lead on a region of a crest. Activate the Sound Generator and observe the plot of pressure. (Your screen should look something like the following image.)

- Now pause the simulator, and begin "stepping forward" by pressing [▶|]
- Observe the plot of pressure and compare the readings. Describe what you see:

- Why do you think the pressure is high in a crest and low in a trough? Recall that sound waves are longitudinal waves of compressions and rarefactions

3) Now observe the effect of two slits using water waves, sound waves, or light waves. Two slits are used to create two new waves with the same amplitude, period, and frequency. This helps scientists observe how two such waves will interfere. Scientists have used two slits to prove that light acts as waves; diffracting and creating areas of interference just like water or sound.