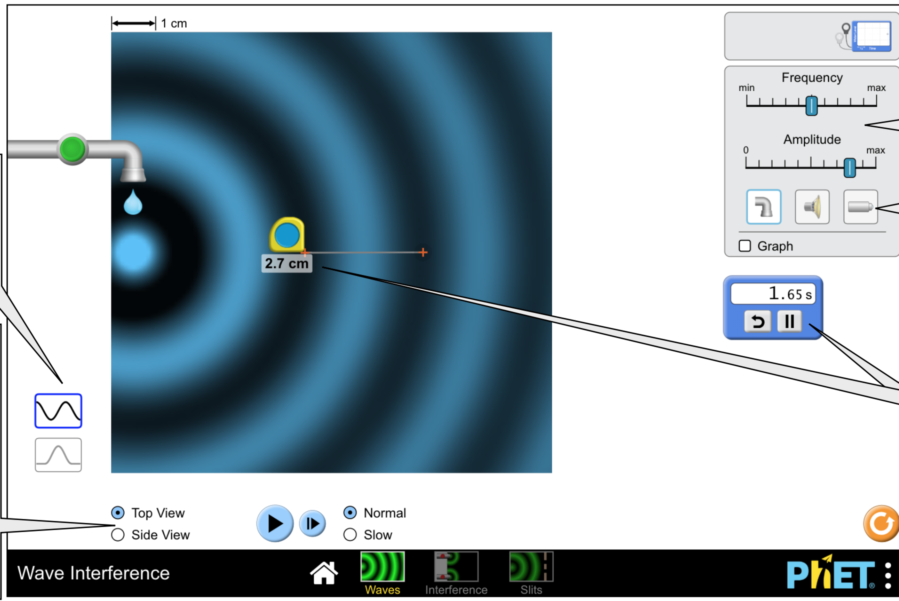
# PhET Tips for Teachers — Wave Interference

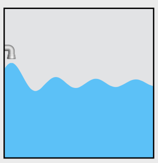
## Waves Screen

Make waves with a dripping faucet, speaker, or laser. Adjust the frequency and amplitude, and observe the changes in the wave.




**GENERATE** continuous wave or pulse

**VIEW** wave from the top or side



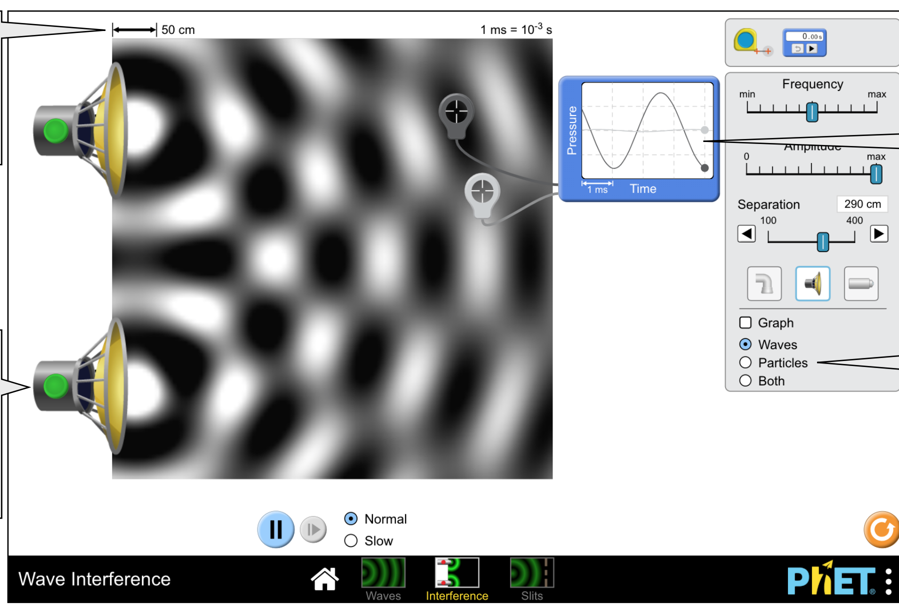
**ADJUST** frequency and amplitude

**EXPLORE** water, sound, or light waves

**MEASURE** wavelength or speed

## Interference Screen

Explore how a pair of wave sources create an interference pattern. Find points of constructive and destructive interference by eye, and by using the detectors.

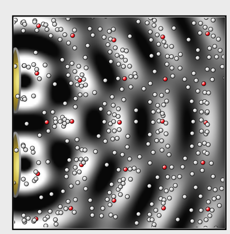



**OBSERVE** the distance and time scale

**CREATE** an interference pattern with two sources

**COMPARE** amplitude and phase

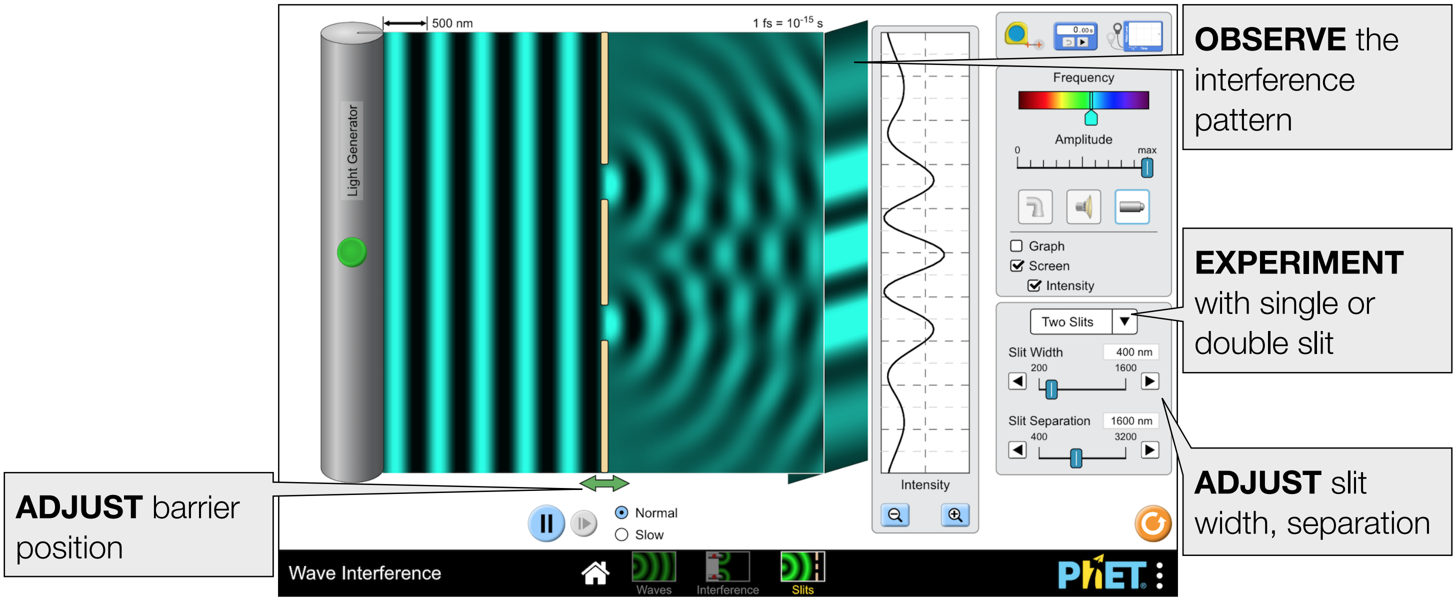
**SEE** particle or wave view of sound



Rouinfar, November 2021

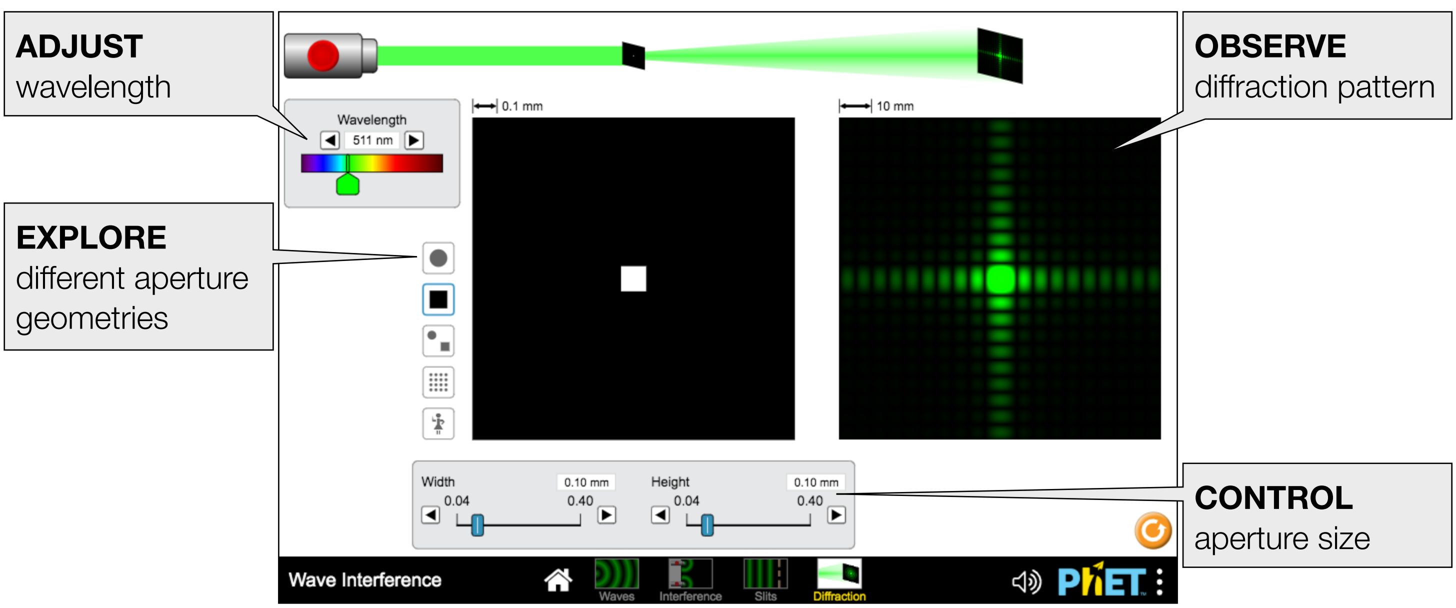
## Slits Screen

Put up a barrier to see how the waves move through one or two slits, and discover the resulting interference pattern. Determine how to change the pattern by adjusting the slit width and separation.




## Diffraction Screen

Experiment with diffraction through elliptical, rectangular, or irregular apertures. Adjust the aperture dimensions and/or wavelength to discover the effect on the diffraction pattern.




Rouinfar, November 2021

## Customization Options

Query parameters allow for customization of the simulation, and can be added by appending a '`?`' to the sim URL, and separating each query parameter with a '`&`'. The general URL pattern is:
`…html?queryParameter1&queryParameter2&queryParameter3`

For example, in Wave Interference, if you only want to include the 1st and 2nd screens (`screens=1,2`), with the 2nd screen open by default (`initialScreen=2`) use:
https://phet.colorado.edu/sims/html/wave-interference/latest/wave-interference_all.html?screens=1,2&initialScreen=2

To run this in Spanish (`locale=es`), the URL would become:
https://phet.colorado.edu/sims/html/wave-interference/latest/wave-interference_all.html?locale=es&screens=1,2&initialScreen=2

| Query Parameter and Description | Example Links |
|---|---|
| `theory` - enable an overlay that displays the theoretical location of interference maxima (yellow lines) and minima (red lines) on the Interference and Slits screens. | `theory` |
| `screens` - specifies which screens are included in the sim and their order. Each screen should be separated by a comma. For more information, visit the Help Center. | `screens=1`<br>`screens=2,1` |
| `initialScreen` - opens the sim directly to the specified screen, bypassing the home screen. | `initialScreen=1`<br>`initialScreen=3` |
| `locale` - specify the language of the simulation using ISO 639-1 codes. Available locales can be found on the simulation page on the Translations tab. Note: this only works if the simulation URL ends in "_all.html". | `locale=es` (Spanish)<br>`locale=fr` (French) |
| `audio` - if muted, audio is muted by default. If disabled, all audio is permanently turned off. | `sound=muted`<br>`sound=disabled` |
| `allowLinks` - when `false`, disables links that take students to an external URL. Default is `true`. | `allowLinks=false` |

## Model Simplifications

- The color maps to the amplitude of the wave. To improve the appearance of the nodes, while maintaining balance between the apparent widths of the maxima and minima, this color-mapping is piecewise defined. Amplitudes greater than zero linearly map to color values of 40%-100%, while amplitudes less than zero linearly map to color values of 0%-40%.
- Before the laser is turned on, the wave viewing window is black, suggesting that the light propagates into vacuum. However, when the laser is running, black represents a trough.

- Due to the different time scales across the water, sound, and light scenes, the next frame button will advance time by a different amount in each scene.
- The boundaries of the wave viewing window are absorbing, but there are still some artifacts due to internal reflections. This can result in some noise in the Screen and Intensity curve, which is smoothed by displaying time-averaged data.
- The particle view of sound can only support one frequency at a time. Changing the frequency will lead to temporary misalignment between the particles and the wavefronts at the previous frequency.
- The plane wave source on the Slits screen is generic. Due to the nature of the model, changing the amplitude will instantaneously change the amplitude for the entire plane wave to the left of the barrier.
- Certain changes will instantaneously clear (or partially clear) the wave viewing area — changing the source separation (Interference), moving the barrier (Slits), changing the frequency (light on all screens, all sources on Slits).
- The diffraction pattern is computed as the fast Fourier transform (FFT) of the aperture pattern.
- The FFT is independent of wavelength. To simulate the effect of changing wavelength, we adjust the size of the aperture in the model, but leave the aperture in the view unchanged.
- The diffraction pattern from a monochromatic source is monochromatic. However, due to the nuances of color perception (nonlinear, color-dependent, saturation-dependent) some diffraction patterns may appear to be multi-colored.

## Suggestions for Use

**Sample Challenge Prompts**

- How does changing the frequency and amplitude affect the characteristics of the waves? How are the water droplet and speaker affected?
- Design an experiment to measure the speed of the wave. How does your measurement compare to the accepted value of the speed of sound or light? How can you explain the discrepancies between your calculated value and the accepted value?
- Create an interference pattern with two sources, and determine the ways to change the pattern.
- Identify points of constructive and destructive interference by eye, and by using the wave detector.
- Compare single-slit diffraction and double-slit interference. How are the patterns on the screen similar? Determine the ways to change this pattern.
- For two slits, use the equation $d \sin\theta = m\lambda$ to predict to where on the screen the maxima will appear. Use the tape measure to verify your predictions.
- Explain how the aperture geometry relates to the diffraction pattern.
- Predict how changing the wavelength or aperture size affects the diffraction pattern.

See all published activities for Wave Interference here.
For more tips on using PhET sims with your students, see Tips for Using PhET.

# Wave Interference PhET Activity

Mr. McCormick, DP Physics                    Name________________________

1. Open the "Wave Interference" simulation on PhET . Click on the "Interference" simulation from the menu.
2. Click on the speaker to go to the audio wave simulation.

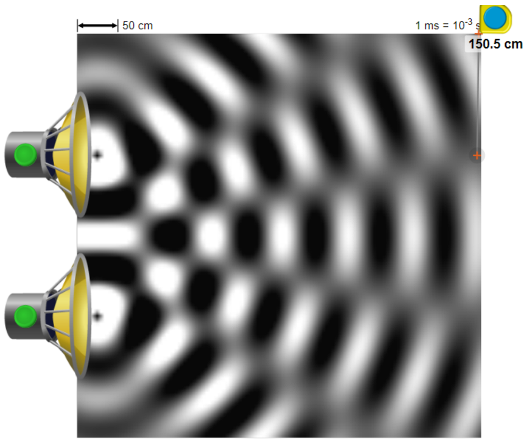
3. Set the frequency and amplitude to "Max", and then press the green button on both speakers to generate sound waves.
   a. Are these waves *coherent* or *incoherent*? How do you know?

   b. Using the tools available to you, try to determine the *wavelength* of the waves being generated in *centimeters*.
      *(Hint: Pausing the simulation and using slow-motion may help with these!)*

   c. Using the tools available to you, try to determine the *frequency* of the waves being generated in Hertz:

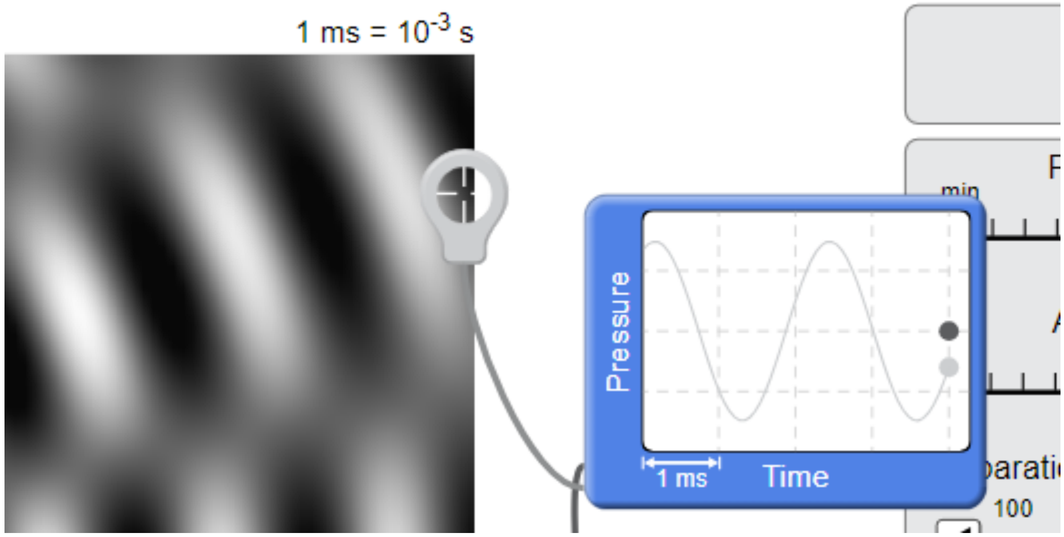
   d. Determine the speed of sound (*in m/s*) through this medium using the information you've gathered so far:

4. Keep the default separation of the speakers to 200 cm.
    a. Imagine you are an observer at the point indicated below, approximately 150 cm from the top edge of the box:




    b. Measure the *path length* between the observer and the top speaker (Measure to the *origin* of the sound wave).
    c. Measure the *path length* between the observer and the *bottom* speaker.
    d. What is the *difference* between these two path lengths? at the observer's position?
    e. Describe the mathematical relationship between the path difference and the wavelength of the waves that you found in part 3a.
    f. Use the blue oscilloscope to measure the amplitude of the wave at the observer's point. What do you notice? What is this called?

g. Now use the blue oscilloscope to find an area of the wave at the edge of the screen with *maximum* amplitude.




h. Repeat steps b-d for *this* point and record your findings below:

Path length top speaker:

Path length bottom speaker:

Path difference:

i. Describe the mathematical relationship between the path difference and wavelength at *this* point. What is happening *here*?

4. How does changing the frequency of the sound waves change the interference pattern that you see on screen?

5. How does changing the separation of the speakers change the interference pattern that you see on screen?