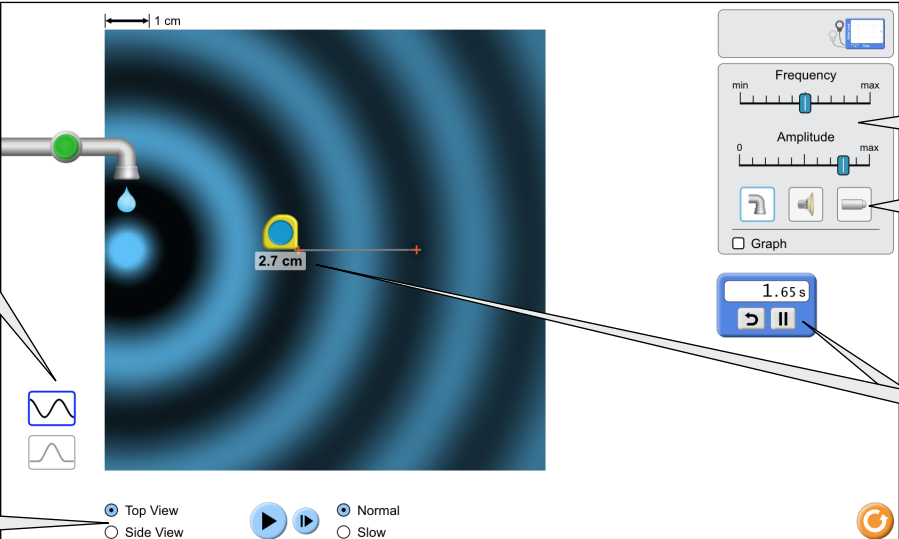


Waves Screen

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

1 cm

2.7 cm

Frequency

Amplitude

Graph

1.65 s

Top View

Side View

Normal

Slow

Wave Interference

Waves

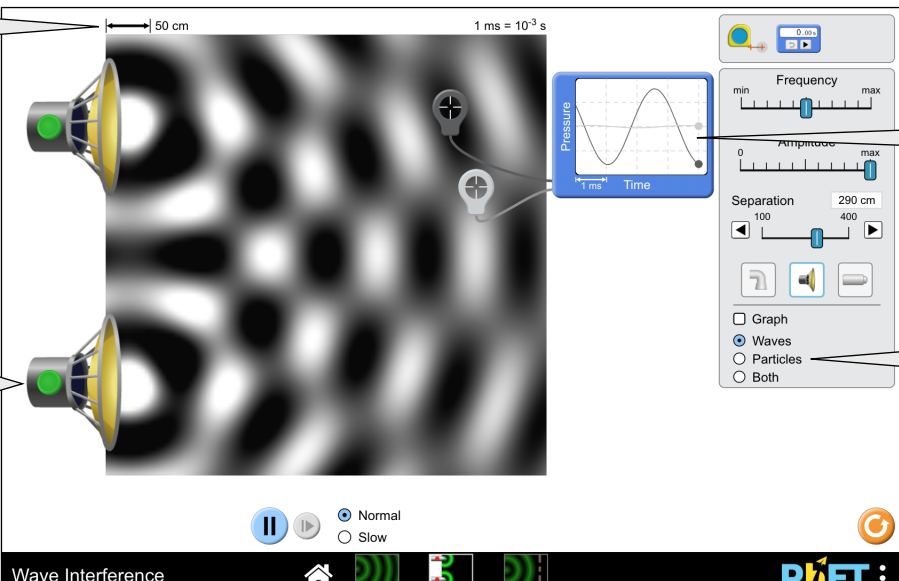
Interference

Slits

PhET

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

50 cm

1 ms = 10^{-3} s

Pressure

Time

Frequency

Amplitude

Separation

Graph

Waves

Particles

Both

Normal

Slow

Wave Interference

Waves

Interference

Slits

PhET

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.

The screenshot shows the PhET Slits Screen simulation. On the left, a 'Light Generator' emits a red laser beam with a wavelength of 500 nm and a frequency of $1 \text{ fs} = 10^{-15} \text{ s}$. The beam passes through a barrier with two slits, creating an interference pattern of red and blue fringes. A green arrow indicates the barrier's position can be adjusted. On the right, a control panel includes a 'Frequency' slider (0 to max), an 'Amplitude' slider (0 to max), and checkboxes for 'Graph', 'Screen', and 'Intensity'. Below these are sliders for 'Slit Width' (200 to 1600 nm) and 'Slit Separation' (400 to 3200 nm). A 'Two Slits' dropdown menu is also present. At the bottom, a 'Wave Interference' panel shows icons for 'Waves', 'Interference', and 'Slits', along with a 'PhET' logo. Callout boxes provide instructions: 'ADJUST barrier position' points to the barrier, 'OBSERVE the interference pattern' points to the fringes, 'EXPERIMENT with single or double slit' points to the 'Two Slits' dropdown, and 'ADJUST slit width, separation' points to the respective sliders.

ADJUST barrier position

OBSERVE the interference pattern

EXPERIMENT with single or double slit

ADJUST slit width, 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.

The screenshot shows the PhET Diffraction Screen simulation. A red laser beam with a wavelength of 511 nm is directed at a black rectangular aperture. The aperture's dimensions are adjustable, with 'Width' and 'Height' sliders ranging from 0.04 to 0.40 mm. The beam passes through the aperture, creating a diffraction pattern of red and blue fringes. A green arrow indicates the aperture's position can be adjusted. On the left, a control panel includes a 'Wavelength' slider (400 to 700 nm) and a 'Frequency' slider (0 to max). Below these are checkboxes for 'Graph', 'Screen', and 'Intensity'. At the bottom, a 'Wave Interference' panel shows icons for 'Waves', 'Interference', 'Slits', and 'Diffraction', along with a 'PhET' logo. Callout boxes provide instructions: 'ADJUST wavelength' points to the 'Wavelength' slider, 'EXPLORE different aperture geometries' points to the aperture shape selection icons, 'OBSERVE diffraction pattern' points to the fringes, and 'CONTROL aperture size' points to the 'Width' and 'Height' sliders.

ADJUST wavelength

EXPLORE different aperture geometries

OBSERVE diffraction pattern

CONTROL aperture size

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 an '&'. 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
<code>theory</code> - enable an overlay that displays the theoretical location of interference maxima (yellow lines) and minima (red lines) on the Interference and Slits screens.	<code>theory</code>
<code>screens</code> - 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 .	<code>screens=1</code> <code>screens=2,1</code>
<code>initialScreen</code> - opens the sim directly to the specified screen, bypassing the home screen.	<code>initialScreen=1</code> <code>initialScreen=3</code>
<code>locale</code> - 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”.	<code>locale=es</code> (Spanish) <code>locale=fr</code> (French)
<code>audio</code> - if muted, audio is muted by default. If disabled, all audio is permanently turned off.	<code>sound=muted</code> <code>sound=disabled</code>
<code>allowLinks</code> - when <code>false</code> , disables links that take students to an external URL. Default is <code>true</code> .	<code>allowLinks=false</code>

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](#).