

Intro Screen

Explore bending of light between two media with different indices of refraction.

VIEW light as a ray or wave

TURN on the laser

DRAG tools from the toolbox

CONTROL the index of refraction of the material

DETERMINE the index of refraction of an unknown

MEASURE the intensity

The interface shows a laser beam passing from air into water, bending towards the normal. A protractor is available in the toolbox. The right panel allows selecting materials (Air, Water, Glass) and setting their index of refraction. A 'Mystery B' material is also available for determination. An intensity meter shows 88.19%.

Prisms Screen

Play with prisms of different shapes and materials, and explore the dispersion of white light.

ROTATE the laser

INVESTIGATE prisms and lenses

CHANGE the environment

CHOOSE monochromatic or white light

SEE reflections

The interface shows a laser beam passing through a triangular prism, dispersing into a spectrum of colors. The right panel allows selecting the environment (Air, Water, Glass) and setting its index of refraction. A color slider is available for choosing monochromatic light. The bottom panel shows various prism and lens shapes, and options for reflections (Normal, Protactor).

More Tools Screen

Control the wavelength of light and explore how it bends between two media using the intensity meter, speedometer, and wave detector.

CHOOSE a wavelength

MEASURE the speed of the wave

VIEW incident, reflected, and refracted angles

COMPARE the phase and amplitude (intensity)

CONTROL the playback speed, and pause/step through the motion

Model Simplifications

- There are many types of glass; we used an index of 1.50 (at 650 nm).
- The intensities of the reflected/refracted light are calculated using the Fresnel equations for "s-polarized" (perpendicular) light.

Reflectance

$$R_{\perp} = \left(\frac{n_i \cos \theta_i - n_t \cos \theta_t}{n_i \cos \theta_i + n_t \cos \theta_t} \right)^2$$

Transmittance

$$T_{\perp} = \frac{4n_i n_t \cos \theta_i \cos \theta_t}{(n_i \cos \theta_i + n_t \cos \theta_t)^2}$$

- There is no attenuation in the simulation, either at surfaces or in vacuum. At each surface, the $Power_{in} = Power_{out}$.
- When showing multiple reflections on the Prisms screen, light rays are terminated after 50 reflections/refractions to ensure computability.
- The index of refraction depends on the speed at which light travels through the medium. This behavior is accurately modeled in this sim, but may be easier to observe on the More Tools screen with the Angles option turned on.

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 Bending Light, 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/bending-light/latest/bending-light_all.html?screens=1,2&initialScreen=2

To run this in Spanish (`locale=es`), the URL would become:

https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_all.html?locale=es&screens=1,2&initialScreen=2

Query Parameter and Description	Example Links
<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>allowLinks</code> - when <code>false</code> , disables links that take students to an external URL. Default is <code>true</code> .	<code>allowLinks=false</code>

Suggestions for Use

Challenge Prompts

- Are the reflection and refraction of light color-dependent? What evidence do you have?
- Explain what happens to a wave when it enters a medium with a higher index of refraction.
- Estimate the index of refraction of the mystery materials. Explain your procedure.

See all published activities for Bending Light [here](#).

For more tips on using PhET sims with your students, see [Tips for Using PhET](#).