

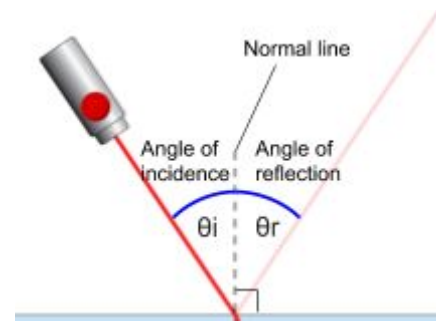
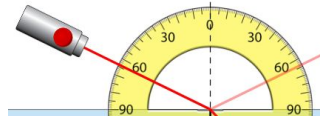
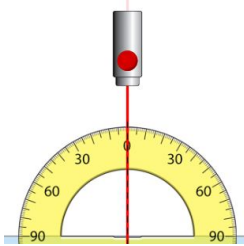
Bending waves Practical

1: Reflection

When waves hit a surface they can be reflected.

Using the simulation answer the questions below.

phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html



1.a. What is the relationship between the angles of **incidence** and **reflection**

1.b What do you notice about the strength of the reflected beam?

1.c Does changing the index of refraction (n) affect the angle of the **reflected** ray?

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2 Refraction

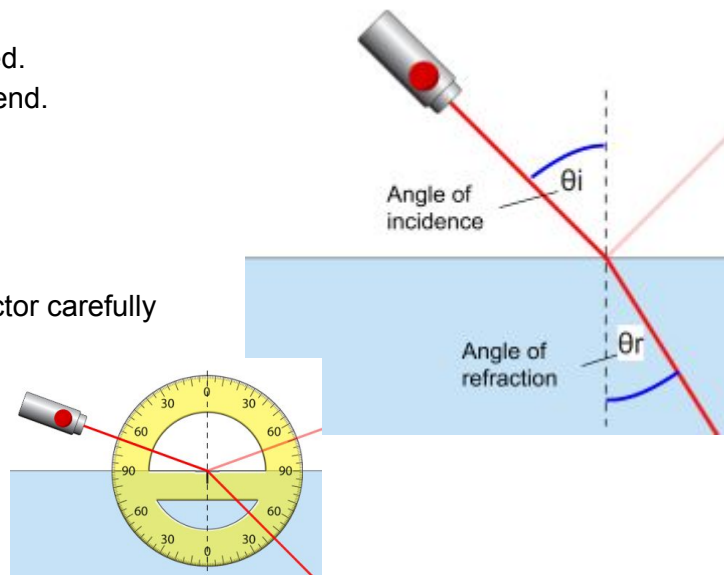
Often part of the wave is transmitted.
If the wave changes speed it will bend.
This is called refraction.



Reset the simulation

Set up the simulation with a protractor carefully placed centered on the normal.

phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html



Complete the table below

Incident angle , θ_i	Refracted angle , θ_r	$\sin(\theta_i)$	$\sin(\theta_r)$	$\sin(\theta_i) / \sin(\theta_r)$
10				
20				
30				
40				
50				
60				
70	45	0.940	0.707	1.____
80				

2.a. What is the relationship between the angles of **incidence** and **refraction**

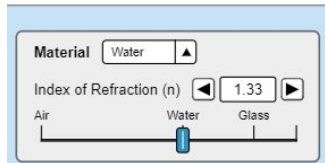
2.b What do you notice about how the strength of the **refracted** beam changes with θ_i ?

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Now try changing the materials at the **bottom** only .

2.c What effect does increasing the index of refraction of the bottom material have?

2.d Does the ray bend toward or away from the normal?
Is that always true when air is the top material?



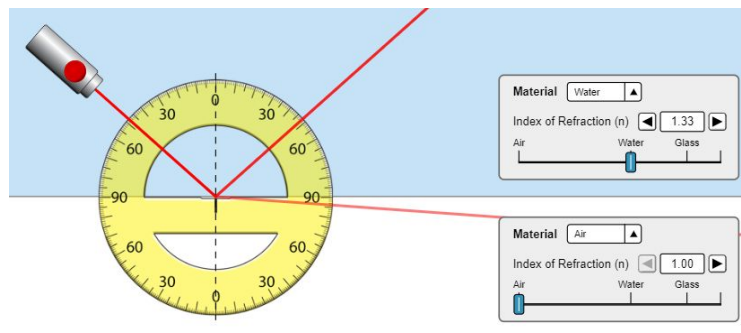
Now try changing **both** the materials .

2.e What patterns do you notice?

2.f How can you make the ray bend away from the normal?

Now set up the materials as **water** on top and **air** on the bottom.

Move the laser back and forth



2.h Somewhere between 30° and 60° the behaviour changes.
What is the exact angle?

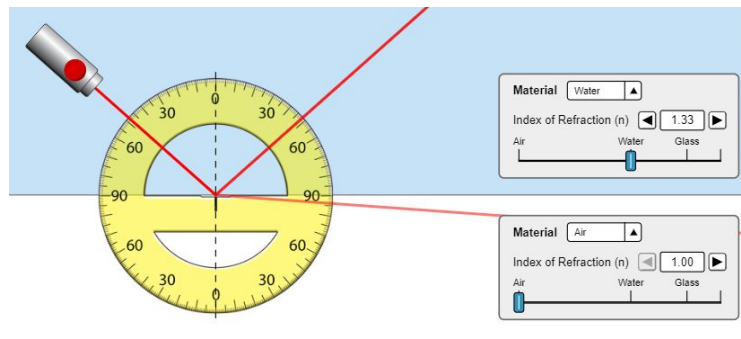
2.i What happens at this angle

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3 Critical angle

When going from a more to a less dense material.

The light ray should be
r_____ away from the
n_____



At the **critical angle** the behaviour suddenly changes and the totality of all light is reflected back internally into the water.

This is called _____ ion

Complete the table below (use **air** as the bottom material)

TOP Material	Refractive index (n)	critical angle θ_c / $^\circ$	$\sin \theta_c$	$1 / \sin \theta_c$
Water	1.33	48	0.743	1.35
Glass				
Mystery A				

3.a. What effect does increasing the index of refraction have on the critical angle?

3.b. What equation can be used to calculate the critical angle c ?

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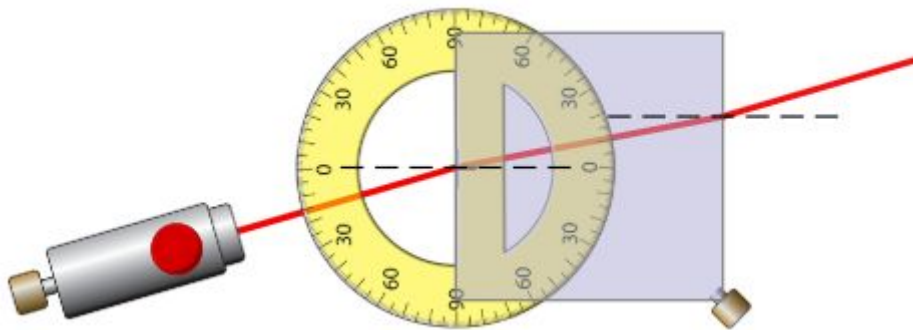
4 “Realistic” Practical (Into more dense)

Go to the Prisms page of the simulation

phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html



Set up the **square glass block**, protractor and ray as shown. Ensure the ray is pointed at the center of the rotated protractor.



Copy your diagram here:

Use: Win + Shift + S or snipping tool

Complete the table below (Use the environment **air**)

Target angle	Incident angle θ_i	Refracted angle θ_r	$\sin(\theta_i)$	$\sin(\theta_r)$	$\sin(\theta_i) / \sin(\theta_r)$
15	13	8	0.225	0.139	1.61
30					
45					
60					
75					

4.a. What is the refractive index, n of the glass?

4.b Which results do you think are the most accurate, small angles or large angles?

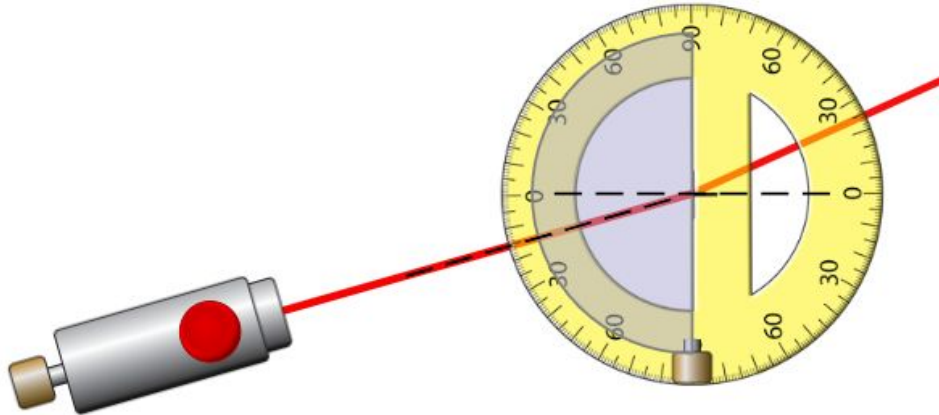
4.c Extension: Calculate the refractive index of Mystery B.

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5 “Realistic” Practical (into LESS dense)

Set up the **semi-circular glass** block, protractor as shown.
 Ensure the ray is pointed at the center of the rotated protractor.
 Use the normal lines to check alignment



Try to complete the table below (Use the environment **air**)

Target angle	Incident angle, θ_i	Refracted angle, θ_r	$\sin(\theta_i)$	$\sin(\theta_r)$	$\sin(i_r) / \sin(r)$	$\sin(r) / \sin(i)$
10						
15	16	24				
20						
30						
40						
50						
60						

5.a. What is the refractive index, n of the glass?

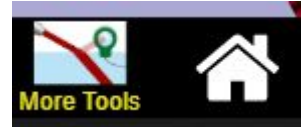
5.b State the largest angle you could find a result for?
 What happened above this angle, why?

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6 The PHYSICS :-)

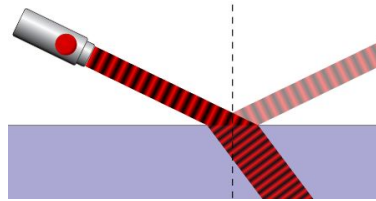
Go to the **More Tools** page of the simulation

phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html



Use the **Wave** setting at 650nm.

Keep the top material as **Air**



6.a. Look at the wavefronts as they enter the glass.

What happens to the **speed**, **wavelength** and **frequency** of the wave? (*by eye*)

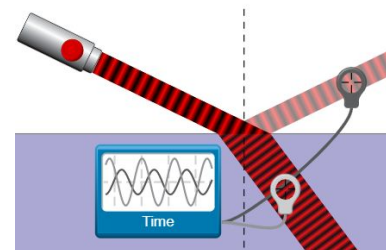
Speed:

Wavelength:

Frequency:

Use the **Time tool** to show the wave of the refracted and reflected rays

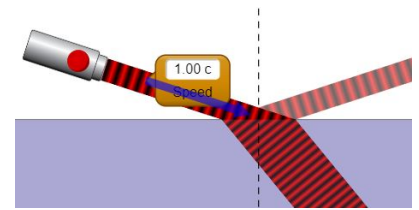
6.b. Are the **frequencies** of the refracted and reflected waves the same or different?



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Use the **Speed tool** to find the velocity of incident, refracted and reflected rays

Bottom material			Wave Speed		
Type	n	1/n	Incident	Reflected	Refracted
Air					
Water	1.33		1.00		0.67
Glass					



6.b. What happens to a wave as it enters a more dense medium.
What is the link between **wave speed** and **index of refraction**

Imagine yourself moving with the wavefronts of light

6.c. As the light enters the bottom material, which side of the ray will slow down first.

6.d. As that side slows down, which way does the ray turn.

Extension:

6.e. Can you imagine a similar situation. E.g. What if a car came off a road into a muddy field?

6.f. Explain in your own words why waves refract when they enter a medium in which they travel more slowly.

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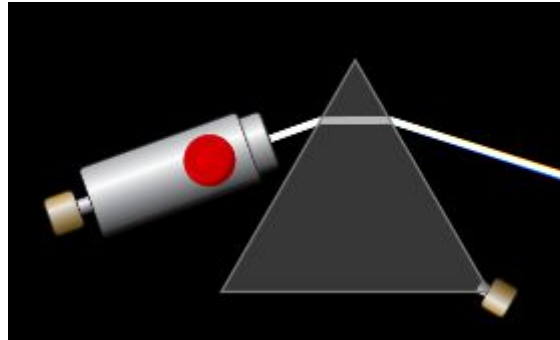
7 The Dark side of the PhET

On the Prisms page of the simulation
phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html



Select the **white on black** colour scheme

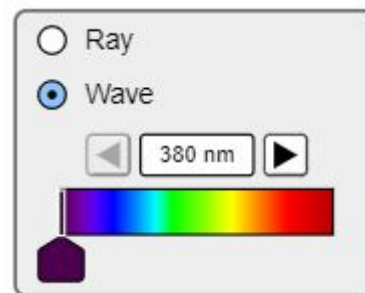
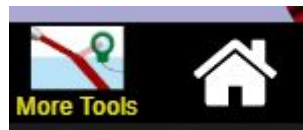
Set up the **triangular** block as shown.
Ensure the ray is pointed near the tip



7.a. Describe what you see.

Go to the **More Tools** page of the simulation

Use the spectrum to
investigate how colour
changes with wavelength



Complete the table

Wavelength nm	400	450	525	580	600	650	700
Colour				Yellow			

7.b. Describe the relationship between colour and wavelength.

7.c. Looking at the spectrum produced by the prism, which colour is bent more?

7.d. Use this to explain which colour slows down the most in a glass block

Bending waves Practical

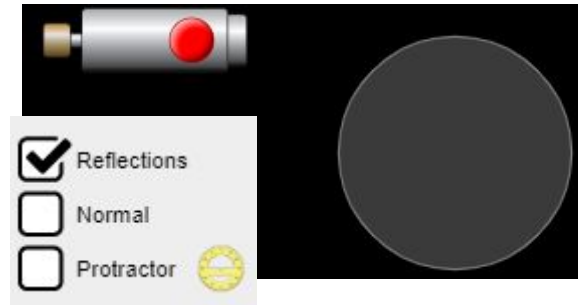
8 Rainbows (Extension)

On the Prisms page of the simulation
[phet.colorado.edu/sims/html/bending-light/
latest/bending-light_en.html](http://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html)



Turn on reflections and use a circular prism

See if you can produce a spectrum.



In a rainstorm lots of small spherical droplets fall from the clouds

Can you explain....

8.a. What conditions are needed for a rainbow

8.b. Is there only one position you might see a rainbow?

8.c. Why are they bows (arcs) [Think about the position of the sun and observer.]

8.d. If you were in a plane, what shape might a rainbow look?

8.e. Could you create one at home?