**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](https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html)





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| 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? |

**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/](https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html)

[latest/bending-light\_en.html](https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html)

Complete the table below

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Incident angle ,θi  | Refracted angle ,θr  | sin(θi)  | sin(θr)  | sin(θi) /sin(θr)  |
| 10 |  |  |  |  |
| 20 |  |  |  |  |
| 30 |  |  |  |  |
| 40 |  |  |  |  |
| 50 |  |  |  |  |
| 60 |  |  |  |  |
| 70 | 45 | 0.940 | 0.707 | 1.\_\_\_\_ |
| 80 |  |  |  |  |

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| 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 θi ? |

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



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| 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 .

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| 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

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| 2.h Somewhere between 30o and 60o the behaviour changes. What is the exact angle?2.i What happens at this angle |

**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** /o | sin ,θ**c** |  1 / sin θ**c** |
| Water | 1.33 | 48 | 0.743 | 1.35 |
| Glass |  |  |  |  |
| Mystery A |  |  |  |  |

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| 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*** ? |

**4 “Realistic” Practical (Into more dense)**

Go to the Prisms page of the simulation

[phet.colorado.edu/sims/html/bending-light/](https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html)

[latest/bending-light\_en.html](https://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 ,θi  | Refracted angle ,θr  | sin(θi)  | sin(θr)  | sin(θi) /sin(θr)  |
| 15 | 13 | 8 | 0.225 | 0.139 | 1.61 |
| 30 |  |  |  |  |  |
| 45 |  |  |  |  |  |
| 60 |  |  |  |  |  |
| 75 |  |  |  |  |  |

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| --- |
| 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. |

**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 ,θi  | Refracted angle ,θr  | sin(θi)  | sin(θr)  | sin(**i**i) /sin(**r**)  | sin(**r**) /sin(**i**) |
| 10 |  |  |  |  |  |  |
| 15 | 16 | 24 |  |  |  |  |
| 20 |  |  |  |  |  |  |
| 30 |  |  |  |  |  |  |
| 40 |  |  |  |  |  |  |
| 50 |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |

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| 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? |

**6 The PHYSICS :-)** 

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

[phet.colorado.edu/sims/html/bending-light/latest/bending-light\_en.html](https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html)



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

Keep the top material as **Air**

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| 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? |

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 |  |  |  |  |  |
|  |  |  |  |  |  |

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| 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

|  |
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| 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:**

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| 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 then enter a medium in which they travel more slowly. |

**7 The Dark side of the PhET**

On the Prisms page of the simulation

[phet.colorado.edu/sims/html/bending-light/](https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html)

[latest/bending-light\_en.html](https://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

|  |
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| 7.a. Describe what you see. |



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



Use the spectrum to

investigate how colour chages 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  |

**8 Rainbows (Extension)**

On the Prisms page of the simulation

[phet.colorado.edu/sims/html/bending-light/](https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html)

[latest/bending-light\_en.html](https://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 rainbow8.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?  |