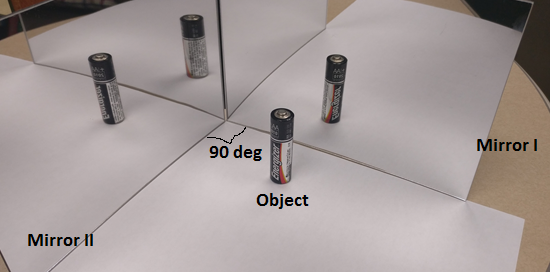
PHYS 202L Reflection and Refraction Remote lab Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

A. Reflection: Plane Mirror

1. Determining the number of images for two plane mirrors kept at a particular angle (θ) between them.   
a. When you stand in front of a plane mirror, you see yourself in the  
mirror. There will be only one image.

|  |  |
| --- | --- |
| θ (degrees) | # of images |
| 180  (use one mirror) |  |
| 120 |  |
| 90 |  |
| 72 |  |
| 60 |  |
| 51.4 |  |
| 45 |  |

b. For θ = 900 is shown below, how many images you see?



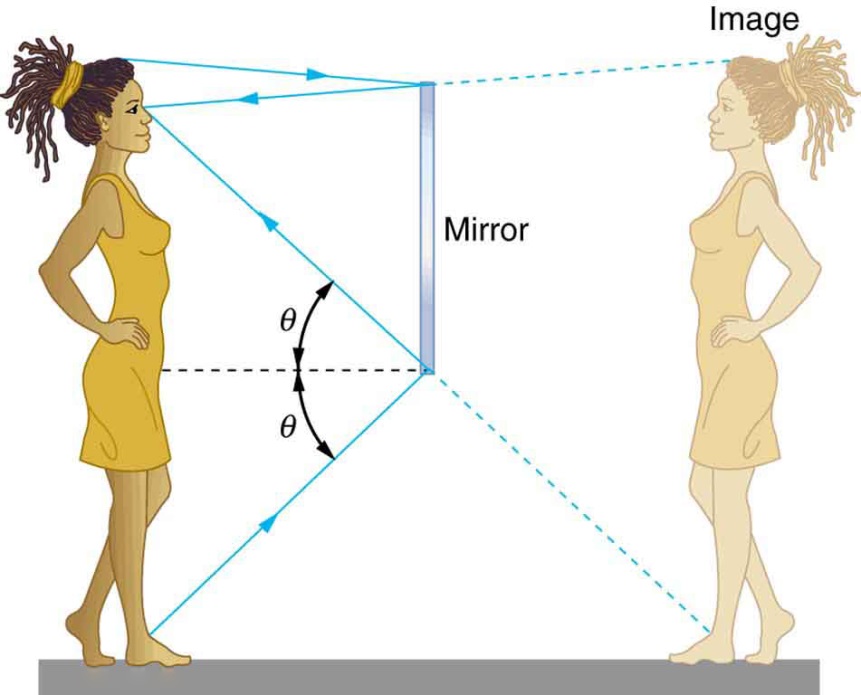
c. Watch this video:   
<https://www.youtube.com/watch?v=ra1SozRvrhE&t=218s>

Write down a formula for the number of images in terms of the angle (θ) between two plane mirrors: # of images = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. Determining the image properties for a plane mirror.   
Using a plane mirror in your home determine the following:

1. Stand in front of it and find out the size of your image. Is it the same or different? Also, is it upright?
2. How far is the image behind the mirror? Observe what happens when you move closer to and away from the mirror.

1. Is the image virtual or real? <https://www.youtube.com/watch?v=g_5_4Ktamf8>

3. Plane mirror size and object size relationship: (Image from OpenStax, College Physics).  


a. Take a piece of paper and cut a square hole inside. Side of the square can have any length as long as it is less than the width of the paper. Tape this cut paper on the mirror, at your eyesight, so that one of the sides of the square is horizontal.

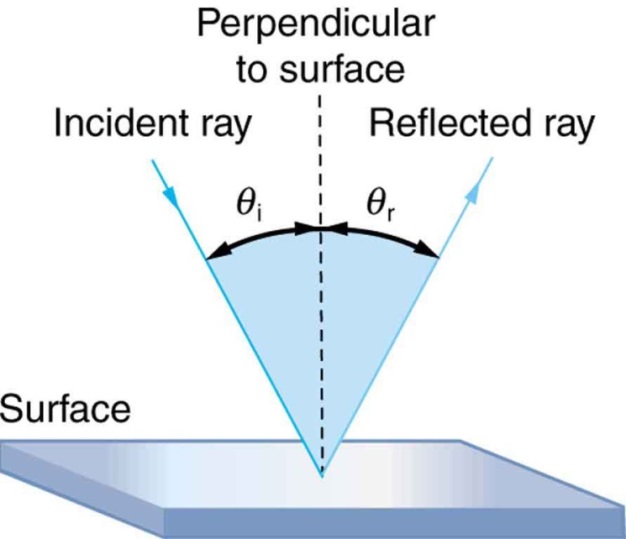
b. Look at the square hole and see how much of your face is inside the square. Measure the size (length or width) of your face as seen inside the square hole of the mirror.   
Size of the side of the square hole =\_\_\_\_\_\_\_\_\_\_\_\_\_  
Size of your face as seen in the square hole of the mirror = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Ratio of size of your face/size of mirror =\_\_\_\_\_\_\_\_\_

c. Repeat the above measurements, for a closer or further distance from the mirror.   
Size of the side of the square hole =\_\_\_\_\_\_\_\_\_\_\_\_\_  
Size of your face as seen in the square hole of the mirror = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Ratio of size of your face/size of mirror =\_\_\_\_\_\_\_\_\_

d. Predict a relationship between size of object and minimum size of mirror to see the entire object in the mirror.  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

e. What minimum height of mirror is necessary to see the entire body of a person whose height is 6 feet. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. The law of reflection: (Image from OpenStax, College Physics).  
 The law of reflection says that the angle of incidence is equal to the angle of reflection.  
 *θi* = *θr*.



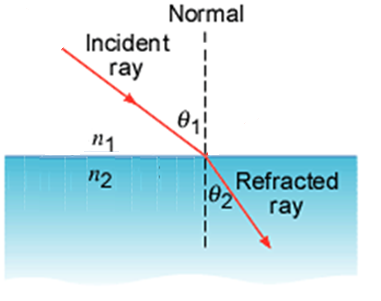
Go to this Phet simulation: (We will use this for the rest of the lab)  
<https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html>

1. Click the first simulation, Intro.
2. Turn on the laser beam by clicking the red button.
3. For this activity you will consider the reflection from the air-water boundary.
4. Click and move the center of the protractor to the reflection point.
5. Move the laser until the angle of incidence is 200.
6. Measure the angle of reflection, and enter the data in the data table.
7. Repeat the measurements for other angles of incidence and complete the data table.
8. Look at your data and explain whether the

|  |  |
| --- | --- |
| θi (degree) | θr (degree) |
| 20 |  |
| 30 |  |
| 40 |  |
| 50 |  |
| 60 |  |
| 70 |  |
| 80 |  |

law of reflection is verified or not, below.

B. Law of Refraction (Snell’s Law):



When light travels from a material with refractive index *n1* into a material with refractive index *n2* the refracted ray, the incident ray, and the normal lie in the same plane. The angle of refraction θ2 is related to the angle of incidence θ1 by:   
 *n*1 sin *θ1* = *n*2 sin *θ2*

B1. Go to this Phet simulation:   
<https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html>

1. Click the first simulation, Intro.
2. Turn on the laser beam by clicking the red button.
3. For this activity you will consider the refraction from air into water.
4. Click and move the center of the protractor to the refraction point.
5. Move the laser until the angle of incidence is 100.
6. Measure the angle of refraction and enter the data in the data table in excel.
7. Repeat the measurements for other angles of incidence and complete the data table in excel.
8. Plot a graph and obtain the index of refraction of water from the graph.

|  |  |  |  |
| --- | --- | --- | --- |
| θ1 (degree) | θ2 (degree) |  |  |
| 10 |  |  |  |
| 20 |  |  |  |
| 30 |  |  |  |
| 40 |  |  |  |
| 50 |  |  |  |
| 60 |  |  |  |
| 70 |  |  |  |
| 80 |  |  |  |

Index of refraction of water from graph = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Accepted index of refraction of water = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

% Error =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

B2. Index of refraction of glass:   
1. Change the refraction medium to glass, by clicking the up arrow for materials (bottom right) and choosing glass.  
2. For this activity you will consider the refraction from air into glass.   
3. Move the laser until the angle of incidence is 100.  
4. Measure the angle of refraction and enter the data in the data table in excel.  
5. Repeat the measurements for other angles of incidence and complete the data table in excel.  
6. Plot a graph and obtain the index of refraction of glass from the graph.

|  |  |  |  |
| --- | --- | --- | --- |
| θ1 (degree) | θ2 (degree) |  |  |
| 10 |  |  |  |
| 20 |  |  |  |
| 30 |  |  |  |
| 40 |  |  |  |
| 50 |  |  |  |
| 60 |  |  |  |
| 70 |  |  |  |
| 80 |  |  |  |

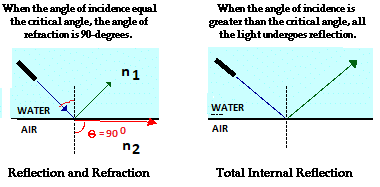
Index of refraction of glass from graph = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Accepted index of refraction of glass = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
 % Error =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

B3. Index of refraction of Mystery A:   
1. Change the refraction medium to Mystery A, by clicking the up arrow for materials (bottom right) and choosing Mystery A.   
2. For this activity you will consider the refraction from air into Mystery A.   
3. Move the laser until the angle of incidence is 100.  
4. Measure the angle of refraction and enter the data in the data table in excel.  
5. Repeat the measurements for other angles of incidence and complete the data table in excel.  
6. Plot a graph and obtain the index of refraction of Mystery A from the graph.

|  |  |  |  |
| --- | --- | --- | --- |
| θ1 (degree) | θ2 (degree) |  |  |
| 10 |  |  |  |
| 20 |  |  |  |
| 30 |  |  |  |
| 40 |  |  |  |
| 50 |  |  |  |
| 60 |  |  |  |
| 70 |  |  |  |
| 80 |  |  |  |

Index of refraction of Mystery A from graph = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

C. Total Internal Reflection and Critical Angle

1. Watch the following video and get an understanding of Total Internal Reflection:   
<https://www.youtube.com/watch?v=QFYWPamx9F8>  
2. Go to the simulation. Change the first medium to water, by clicking the up arrow for materials (top right) and choosing Water. Change the second medium to air, by clicking the up arrow for materials (bottom right) and choosing Air.  
3. First you will consider the refraction from water to air.  
4. Change the angle incidence by moving the laser and make the refracted ray to grace the boundary. In this case θ2 = 900 and θ1 = θC.   
5. Record the critical angle, θC for the water-air boundary.  
6. Calculate the critical angle, θC for the water-air boundary.   
  


Applying the Snell’s law gives: , Since Sin 900 = 1.

|  |  |  |  |
| --- | --- | --- | --- |
| Boundary | Critical Angle θC (degree) | | % Error |
| Measured | Calculated |
| Water(n=1.33)-Air(n=1) |  |  |  |
| Glass(n=1.50)-Air(n=1) |  |  |  |
| Glass(n=1.50)-Water(n=1.33) |  |  |  |

7. Change the first medium to Glass, by clicking the up arrow for materials (top right) and choosing Glass. Change the second medium to Air, by clicking the up arrow for materials (bottom right) and choosing Air. Repeat the measurements and calculations for Glass-Air boundary and complete the data table.  
  
8. Change the first medium to Glass, by clicking the up arrow for materials (top right) and choosing Glass. Change the second medium to Water, by clicking the up arrow for materials (bottom right) and choosing Water. Repeat the measurements and calculations for Glass-Water boundary and complete the data table.  
  
9. Write an overall conclusion for the entire lab.