

Lab 08 - Wave Nature of Light

NAME: _____

Time spent on Lab 08 = approximately 2 hours, does not need to be done at one sitting

Materials needed = Access to computer and high speed internet, Java installed on the computer

Learning Objectives:

- Use geometry to manipulate sources of light
- Analyze the results of the this manipulation to interpret physical properties

First proceed to the following website and download the Java file:

<https://phet.colorado.edu/en/simulation/wave-interference>

Once the Java file is open, you should see something like the screenshot below:

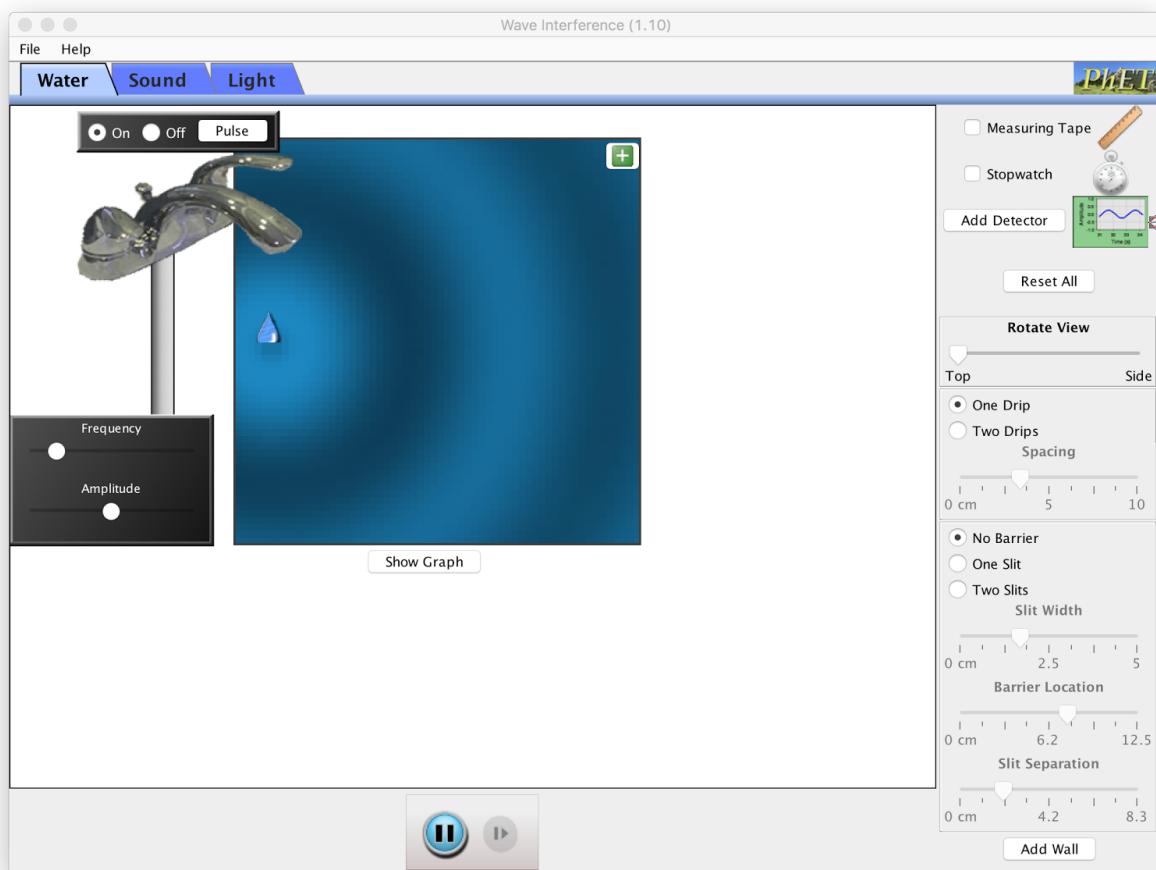


Figure #1

Before we begin experimenting with light, take a few minutes to watch this video:

https://www.youtube.com/watch?v=J_xd9hUZ2AY

And keep the simulator on the first tab to experiment with creating water waves!

The photograph below shows the interference of two water waves produced by two coherent sources operating at the same frequency and in phase. The waves travel outward at a constant speed from the two sources at the center bottom of the picture.

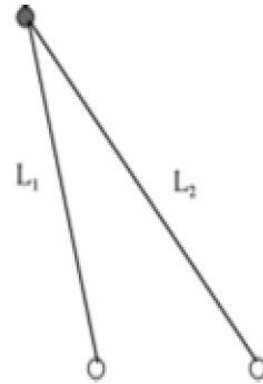
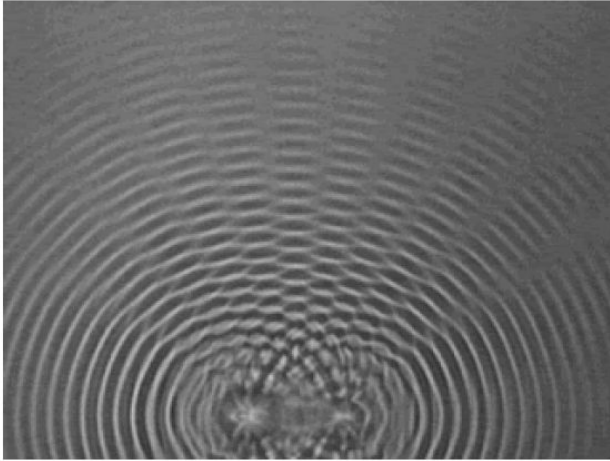


Figure #2

1. Describe the pattern produced by the interfering waves.

Now in the simulator, select “Light” as the wave source. There should now be one light source producing a red wave as shown below:

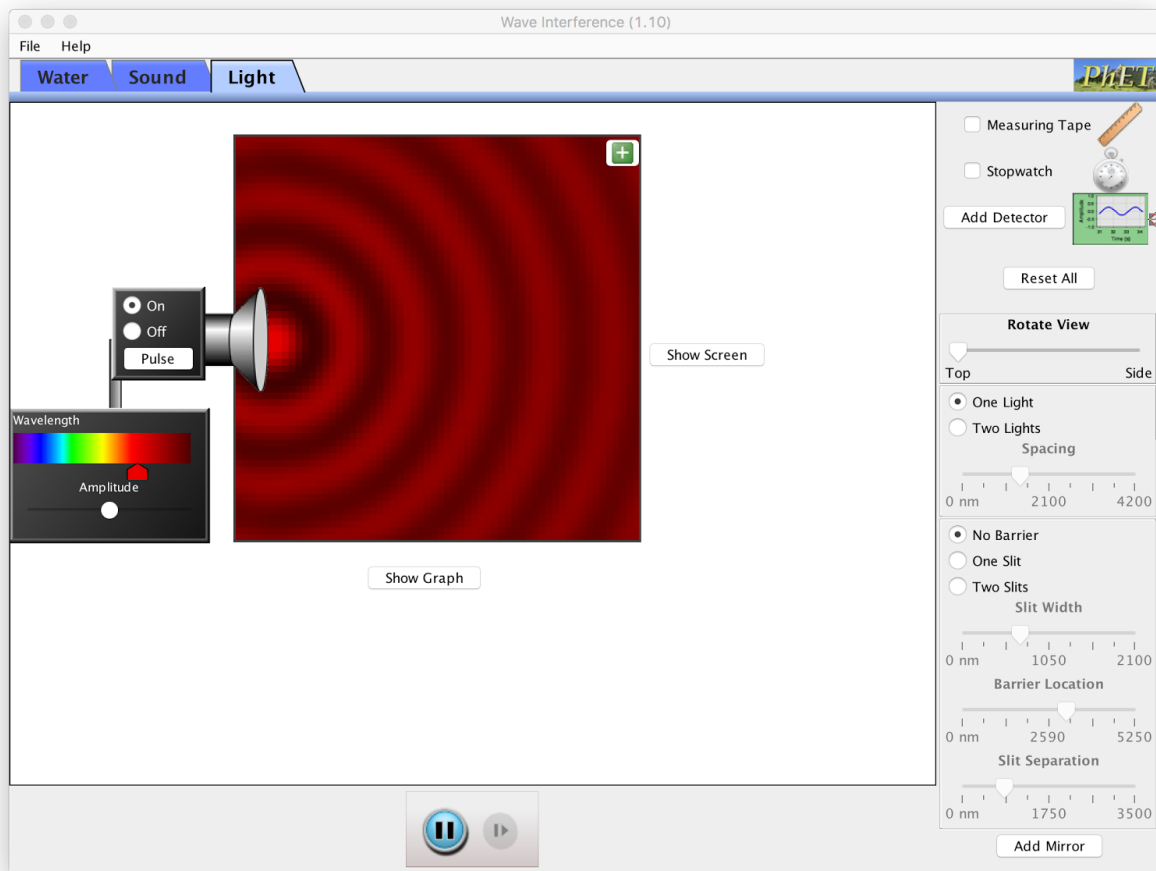


Figure #3

This is a top down view depicting the peaks of circular light waves as red rings and the troughs of these circular waves as the black rings.

2. Measure the wavelength of the light wave being produced. You will want to use the simulator's measuring tape.

3. Turn on the second light source. Explore the effect of changing the separation between the two sources on the interference pattern. Describe your observations.

Now set the source separation to be $3.5 \times$ the wavelength you measured in #2.

4. Locate two positions of maximum field movement above the central point. Using the simulation's tape measure, precisely measure the distance from each source to each maximum as shown in figure #2. Organize your data in the table below. You may want to expand the simulator size for ease of measuring, and "show the screen" to better view where maximums occur.

Measurement #	L_1	L_2	$L_2 - L_1$	$(L_2 - L_1)/\lambda$
1				
2				
3				

5. Calculate the difference in the distance of each source to each maximum and then divide by the wavelength and record your answers in the last column of the table above.

6. What relationship between the differences and the wavelength best describes your data? Why?

- a. $L_2 - L_1 = n\lambda$, where $n = 0, 1, 2, 3, \dots$
- b. $L_2 - L_1 = (n+0.5)\lambda$, where $n = 0, 1, 2, 3, \dots$

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7. Now locate two positions of minimum field movement above the center. Measure the distance from each source to each maximum. Organize your data in a table.

Measurement #	L_1	L_2	$L_2 - L_1$	$(L_2 - L_1)/\lambda$
1				
2				

8. Calculate the difference in the distance of each source to each minimum and then divide by the wavelength and record your answers in the last column of the table above.

9. What relationship between the differences and the wavelength best describes your data? Why?

- a. $L_2 - L_1 = n\lambda$, where $n = 0, 1, 2, 3, \dots$
- b. $L_2 - L_1 = (n+0.5)\lambda$, where $n = 0, 1, 2, 3, \dots$

The two-slit experiment is a method of producing two sources of coherent light waves, which can interfere with each other. A source of monochromatic light of wavelength λ is incident on two slits separated by a distance d . A screen is placed a distance L away. A diagram below illustrates this experimental setup.



Figure #4

10. Imagine plane waves (light waves from a distant source or from a laser) hitting the two slits on the left. Why might you consider the waves emerging from the slits to be from two coherent sources of light waves?

11. We want to predict the positions P that will give us either a dark spot or a bright spot. Let's step through the argument for predicting a maximum. In the picture below, identify *only* the path length *difference* between the light reaching P from the two slits. Indicate it with the Greek letter δ .

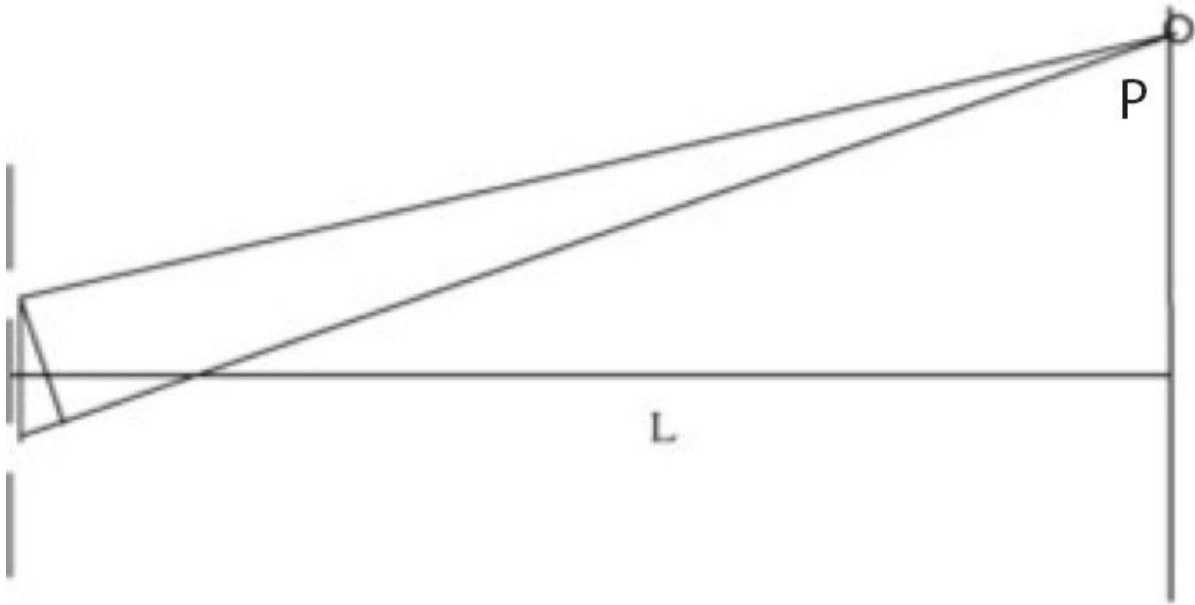


Figure #5

12. If the point P is a maximum then what must the path length difference, δ , be in terms of the wavelength? (Recall your work in the data tables above)

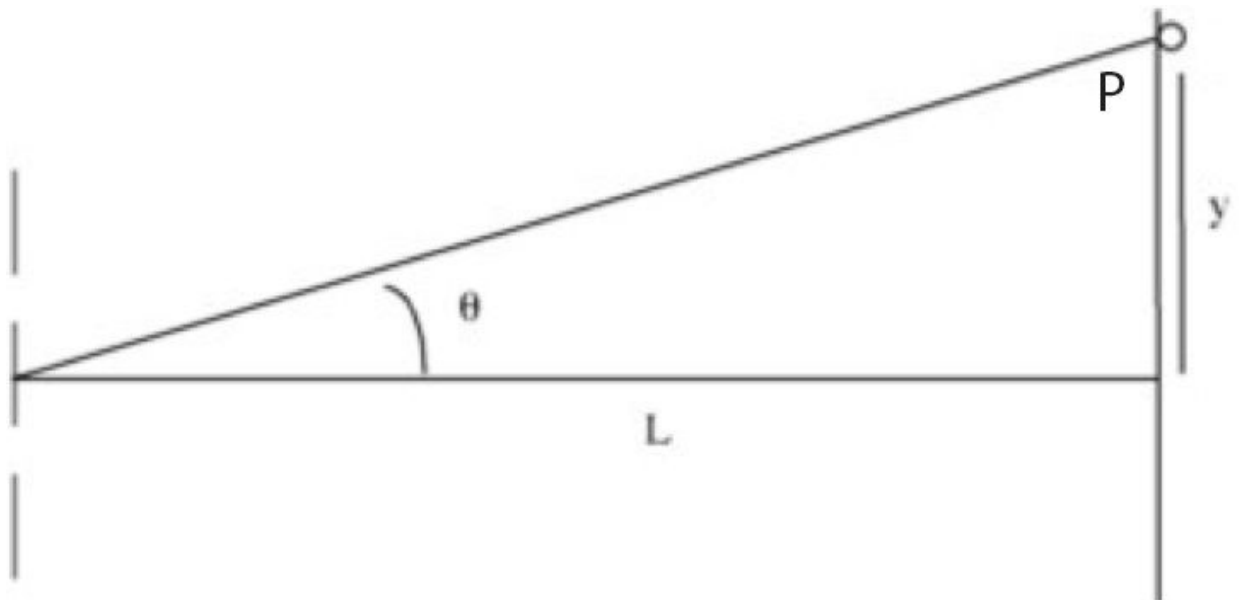


Figure #6

13. Now express δ in terms of d and $\sin \theta$.

14. Combine your expressions in 12 and 13, and write the resulting equation in the space below.

15. Now, using the small angle approximation, $\theta \approx \sin\theta \approx \tan\theta$, for angles less than about 20° , solve for y (the position on the screen) in terms of λ , L and d .

16. What is the equation that gives the positions of the minimums along the screen?

17. If you increase d , the distance between the slits, what should happen to the bright spots on the screen?

In summary, waves can interfere with one another and produce constructive and destructive interference fringes. And when light waves pass through slits that are small compared to the wavelength of the light, the waves can spread out and actually bend around corners! In this case it does not produce a nice shadow of the slit as you might expect but behaves more like sound waves bending around a doorway (where the width of the doorway is comparable to the wavelength of the sound wave). Any time light waves encounter a very sharp edge or a very small opening a diffraction pattern can develop like the one seen above. If there is time, have your instructor show you the diffraction pattern from a CD or a diffraction grating.

- Portions of this lab were taken from ©Humanized Physics Project (HPP), Doane University.

Once you have completed all lab questions, please download this document as a PDF only! Then upload this PDF to Blackboard under the assignment "Lab 08", for grading.