Course and Section_______ Names ____________________________

Date____________________ ____________________________

# *INTERFERENCE AND DIFFRACTION SIMULATION*

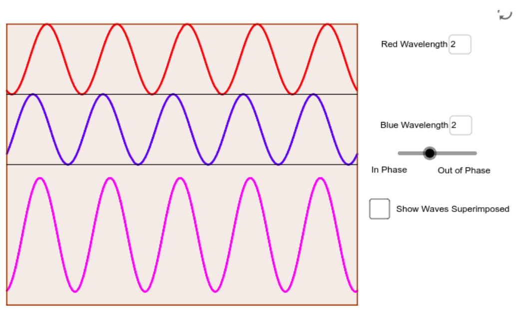
## Introduction

The purpose of this simulation is to investigate the wave nature of light by studying the interference and diffraction patters.

Submit your answers using Blackboard.

## 1 – Wave Interference

Open this simulation (https://www.geogebra.org/m/NwAvP2Dg)




The animation shows a red wave and a blue wave on top, below them there is the wave which occurs when the red and blue waves interfere (the summation of the two). The proprieties of the resulting wave depend on several aspects of how the two original waves are related.

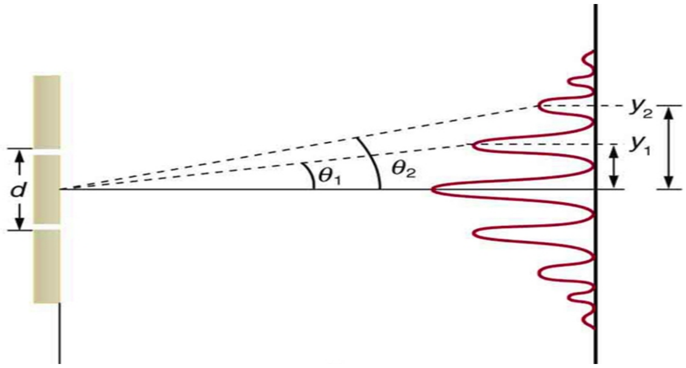
R = amplitude of the red wave , B = amplitude of the blue wave
1. What is the amplitude in the interference wave when the two waves are in phase ?
2. What is the amplitude in the interference wave when the two waves are in out of phase ?

Click the play button located at bottom left
3. Do all the waves travel at the same speed?

Change the wavelength of either one of the waves.
4. Does the interference wave preserve the original sinusoidal shape of the two waves ?
5. Is it possible to generate an interference wave with sinusoidal shape when the red and blue wave have different wavelengths?

## 2 – Double Slit Interference

When light of wavelength λ passes through *two* slits which are separated by a distance *d*, the pattern of the intensity of light on a screen located at a distance *L* from the slits is




location of the **minima** given as

$$(m+1/2)\lambda = d\sin\theta \qquad m = 0,1,2,...$$

location of the **maxima** give as

$$m\lambda = d\sin\theta \qquad m = 0,1,2,...$$

In the approximation of small values of *θ*, the two equations above give the angular locations of the minima and maxima on the the y – axis. We can write these equations in terms of the physical height y from the central peak as shown below

$$y_{min} = \frac{\lambda L}{d}(m+1/2) \qquad m = 0,1,2,...$$

$$y_{max} = \frac{\lambda L}{d}m \qquad m = 0,1,2,...$$

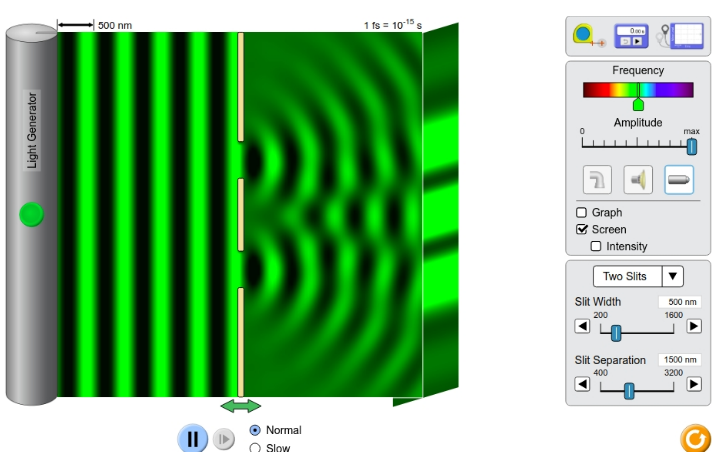
<u>Problem</u>

Light of wavelength 750 nm passes through two slits 0.3 mm apart and forms an interference pattern on a screen 2 m away.

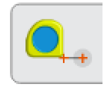
6. What is the angular width of an interference maximum? (deg)

7. What is the width of an interference maximum? (cm)

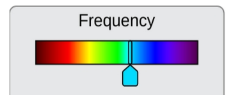
Open the simulation (https://phet.colorado.edu/sims/html/wave-interference/latest/wave-interference_en.html).



Select *Slits*. You can select water, sound or light waves, select the light source. Click to display *Screen* and select *Two Slits* from the drop down menu. Turn on the light generator. To measure the lengths, select the rule located on the top right corner.



Using the green horizontal double arrow at the bottom, move the panel containing the two slits all the way to left, it will be directly next to the light generator. Keep it there.
8. How did the distance between two minima change as you moved the panel with two slits closer to the light source?
9. How does the distance between two minima change if you increase slit separation?




Set the frequency to so that the light generator color = turquoise.
Set the panel containing the two slits as far to the left as possible.
Set slits width = 300 nm, slit separation = 1300 nm. Click to display *Intensity*.

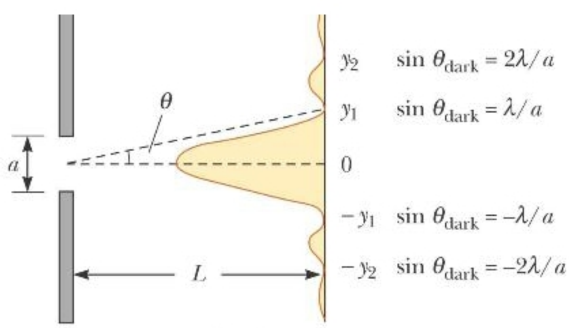
10. What is the distance between two maxima? (nm)

Using the ruler to measure,
11. What is the distance *L* between the screen and the light generator? (nm)
12. Using the formula of the maxima's locations, calculate the wavelength of the turquoise light. (nm)

Now repeat. Set slits width = 300 nm, slit separation = 2200 nm, same *L*.
13. What is the distance between two maxima? (nm)
14. What value for the wavelength of the turquoise light do you obtain now? (nm)
15. Should the two values of the wavelength be the same?

## 3 – Single Slit Diffraction

Diffraction is basically interference of light with itself which occurs when peculiar physical conditions are satisfied. The diffraction pattern has different proprieties than the interference patter and both might be present at the same time. When light of wavelength λ passes through *one* slit of width *a* the pattern for the the intensity of light on a screen located at a distance *L* from the slit is




location of the **minima** is given as

$$m\lambda = a\sin\theta \quad m = 1,2,3,...$$

In the approximation of small values of $\theta$, the equation above provides the locations of the minima on the the $y$ – axis

$$y_{min} = \frac{\lambda L}{a} m \quad m = 1,2,3,...$$

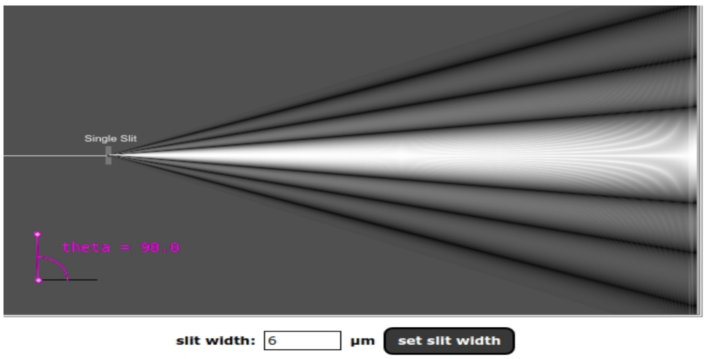
There is not a similar equation to describe the locations of the maxima. A central maximum is located at the center, the others are about half-way between two minima. The width of the central maximum is twice as much of the other maxima.

Problem

Light of wavelength 575 nm passes through a single slit of width 0.1 mm and forms a diffraction patter on a screen 3 m away.

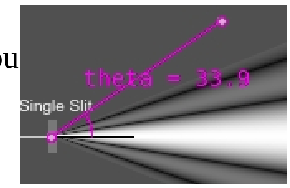
16. What is the angular width of the central diffraction maximum? (deg)
17. What is the width in cm of this maximum on the screen? (cm)

Open the simulation (https://www.compadre.org/Physlets/optics/prob38_4.cfm)




By pressing and holding the left mouse button on the image, the coordinates of a point are displayed in the left bottom corner inside a yellow box. You can use the coordinates to find distances.

18. What happens to the width of the central maximum if you increase the slit width?
19. How far is the screen from the slit? (cm)
20. For the slit width = 10 μm , what is the distance between the minima? (cm)
21. Using the formula of the minima's locations, calculate the wavelength of the light. (nm)



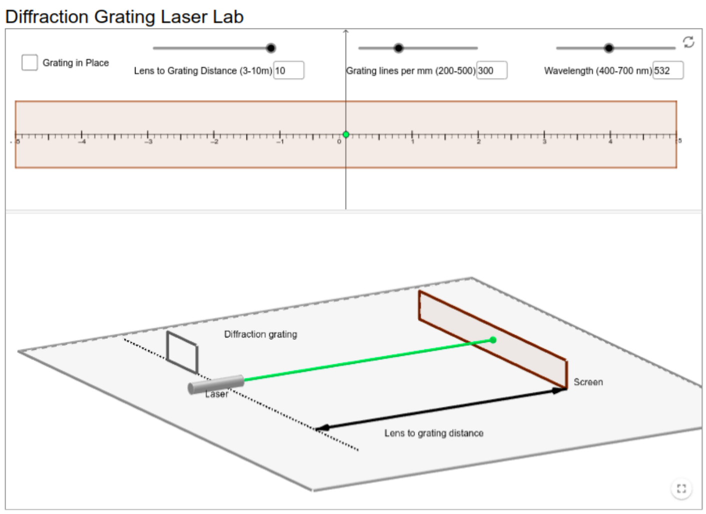

You can also measure angles using the protractor located on the bottom left of the screen. Take the protractor and drag it over the single slit. Once in position you can move the pink bar to take measurements.

With the slit width still set to 10 μm.

22. What is the angular position of the second order minimum ? (cm)
23. Using the formula of the minima's angular location, calculate the wavelength of the light. (nm)
24. Calculate the % difference between your results of the wavelength (question 21 and 23).

## 4 – Diffraction Grating

Open the simulation (https://ophysics.com/l5b.html)




The location of the maxima is the same as the two slits: $m\lambda = d\sin\theta$ $m = 0,1,2,...$ with $d$ being related to the the number of lines per unit length $N$ as $d = 1/N$.

25. If a diffraction grating has 600 lines per millimeter what is $d$? (μm)

When natural light needs to be separated in different wavelengths with high resolution a diffraction grating is a very effective tool because of the quality of the image it produces on a screen.
Click on *Grating in Place* to see the image.

26. If you decrease the distance between the grating and the screen what happens to the distance between maxima?
27. If you decrease the wavelength what happens to the distance between maxima?
28. If you increase $d$ what happens to the distance between maxima?

Set the wavelength to 400 nm, screen at 10 m.
29. What are the units of the scale indicating the distances on the screen?
30. What is $N$ in order for the distance between the zeroth and first order maxima to be 1 unit of the previous question? (lines/mm)