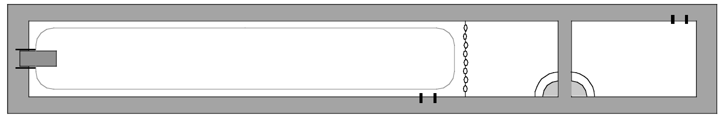
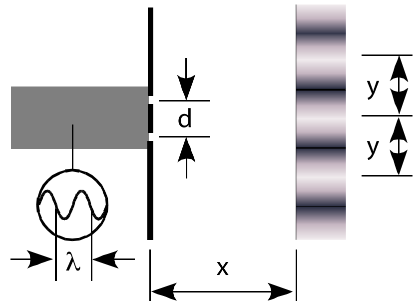
PhyzSpringboard: Interference Math



When a beam of laser light passes through a pair of slits, an interference pattern is produced.

The wavelength of the light is λ, the slit separation distance is *d*, the distance from the slits to the screen is *x*, and the distance from the central maximum to the first order maximum is *y*.

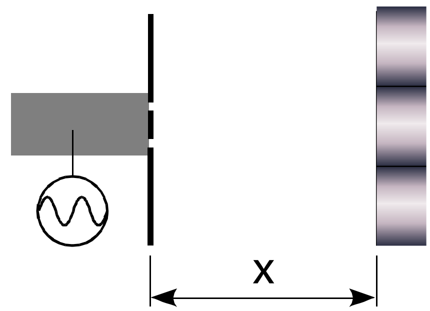


SCREEN DISTANCE

1. If the screen is moved farther from the slits, the first order maximum moves **away from** the central maximum.

Whic relationship, if any, exists between the first order distance, *y*, and the screen distance, *x?*

__$y \propto x$ (y is directly proportional to *x*)
__$y \propto 1/x$ (y is inversely proportional to *x*)
__*y* is independent of *x*

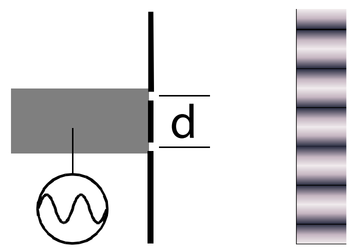


SLIT SEPARATION

2. If the slit separation distance is increased, the first order maximum moves **toward** the central maximum.

What relationship, if any, exists between the first order distance, *y*, and the slit separation distance, *d?*

__$y \propto d$ (*y* is directly proportional to *d*)
__$y \propto 1/d$ (*y* is inversely proportional to *d*)
__*y* is independent of *d*

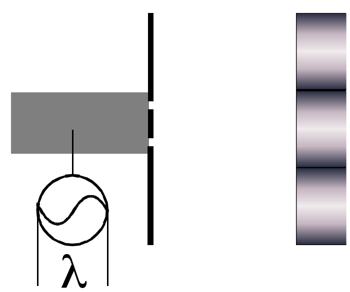


WAVELENGTH

3. If the wavelength of the light is increased, the first order maximum moves **away from** the central maximum.

What relationship, if any, exists between the first order distance, *y*, and the wavelength of the light, λ?

__$y \propto \lambda$ (*y* is directly proportional to λ)
__$y \propto 1/\lambda$ (*y* is inversely proportional to λ)
__*y* is independent of λ

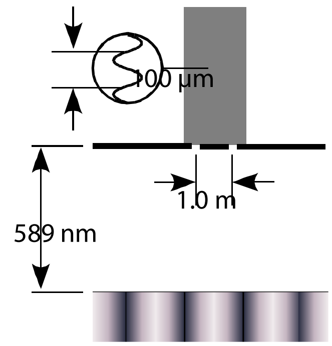


ALL TOGETHER NOW

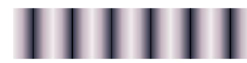
4. Write a single proportionality that describes the dependance of the first order distance on screen distance, slit separation distance, and wavelength.

PATTERN INTERPRETATION

5. Suppose the pattern shown to the right were created by passing 589 nm yellow light through a pair of slits 100 μm apart onto a screen 1.0 m past the slits.



a. A change is made to the apparatus, and the pattern changes to the one shown below and to the right. What might have caused this change? (Select all answers that could have caused the change.)



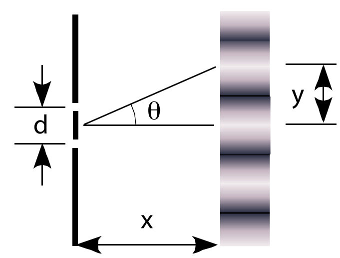
___The yellow light was replaced with red light.
___The yellow light was replaced with blue light.
___The slits were moved closer together.
___The slits were moved farther apart.
___The screen was moved farther from the slits.
___The screen was moved closer to the slits.

b. Suppose the yellow light is replaced with blue light and the screen is kept at a distance of 1.0 m. To keep the pattern from changing, the slits will have to be
___moved together. ___moved apart.

c. Suppose instead that the screen is moved closer to the slits and the slits are kept at 100 μm. To keep the pattern from changing, the wavelength will have to be
___increased. ___decreased.

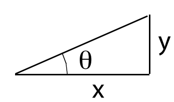
FROM PROPORTIONAL TO EQUAL

6. The proportionality developed in part 4 is perfectly good for understanding the interference pattern and the changes that can be made to it. To get quantitative, though, we will need to refine the proportionality into an equation.

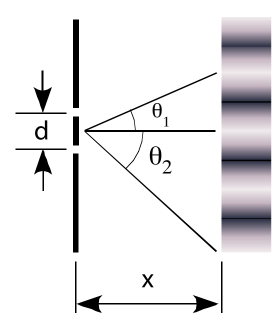


a. Rewrite the proportionality, solving for λ.

b. Bring the angle, θ, into the expression by replacing the ratio of y to x with the tangent of θ.



c. This proportionality is an excellent approximation. But to turn it into an equation, we must replace the tangent function with the sine function. (We will not work out the detailed geometric reasoning for this right now.) Rewrite the proportionality from the last step as an equation, replacing the tangent function with the sine function.



d. This equation can be extended to account for the locations of the maxima beyond the first order as well. The order number is denoted with the letter m, and the angle to the m^{th} order maximum is denoted with the symbol θ_m. Write the final equation.