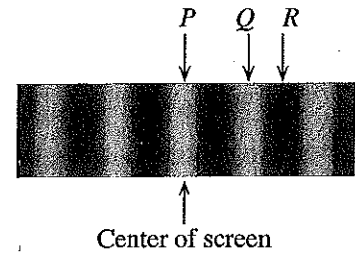


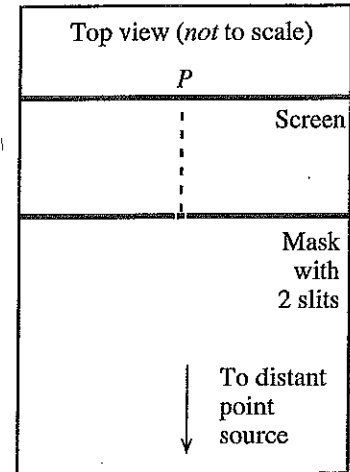
1. A distant point source of red light, a mask with two identical, very narrow slits, and a screen are arranged as shown in the top view diagram below right.

The photograph at right shows the pattern that appears on a distant screen. Point P , the center of the pattern, and point Q are maxima. Point R marks a minimum to the right of point Q .

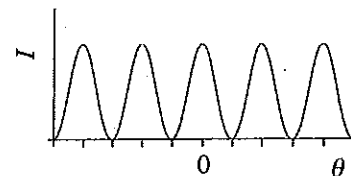


- a. In the space above the photograph at right, clearly label each of the lettered points according to ΔD , the difference in distances from the slits to that point. Express each value of ΔD in terms of λ .
- b. The screen is 2.2 m from the slits, and the distance from point P to point R is 1.6 mm.

Determine the distance between the slits in terms of λ . Show your work and describe any approximations that you make in answering this question.

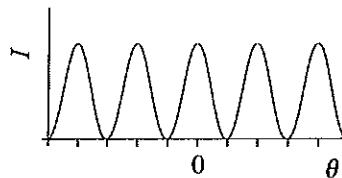


- c. Suppose that the width of the right slit were decreased (without changing the distance between the centers of the slits).
- i. Would the intensity at each of the following points *increase*, *decrease*, or *stay the same*? In each case, explain your reasoning.
- point Q
 - point R
- ii. The graph of intensity (I) versus angle (θ) shown at right corresponds to the above double-slit experiment. (The angle θ is measured relative to the normal to the screen.)



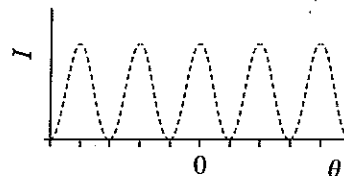
In the space at right, show how the intensity graph would be different if the right slit were made narrower.

2. The graph of intensity *versus* angle at right corresponds to a double-slit experiment similar to the one described in problem 1.

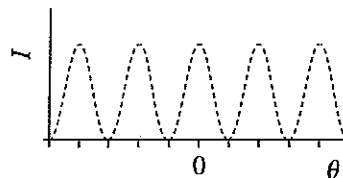


In each part below, suppose that a *single* change were made to the original apparatus. In the spaces provided, show how the graph of intensity *versus* angle would be different from the original graph (shown dashed). In each case, *explain your reasoning*.

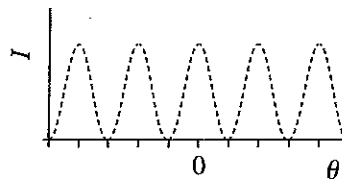
- the distance between the centers of the slits is increased (without changing the width of the slits)



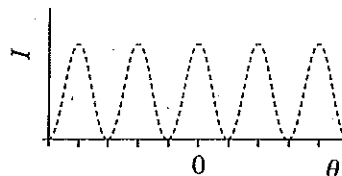
- the wavelength of the incident light is increased



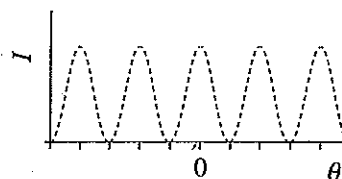
- the distance from the mask to the screen is decreased



- the width of *both* slits is decreased (without changing the distance between the centers of the slits)



- the width of *one* of the slits is decreased (without changing the distance between the centers of the slits) [Sketch the approximate shape of the intensity *versus* angle graph.]



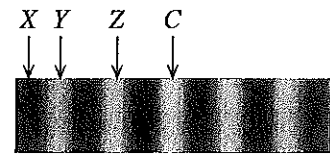
MULTIPLE-SLIT INTERFERENCE

Name _____

Optics
HW-151

1. The photograph at right illustrates the pattern that appears on a distant screen when coherent red light is incident on a mask with two identical, very narrow slits. The two slits are separated by a distance d .

Pattern on screen with two slits



Point C marks the center of the screen. Point X marks a point of zero intensity, and points Y and Z mark maxima.

- a. In the space at right below the photograph, clearly label each of the lettered points according to ΔD , the difference in distances from the slits to that point. Express each value of ΔD in terms of λ .
- b. Suppose that the two-slit mask were replaced by a mask with *five* slits of the same width as the original slits, with adjacent slits separated by the same distance as before.
 - i. Would point X still be a point of zero intensity with the five-slit mask? Explain your reasoning.

- ii. Would point C , the center of the screen, still be a point of maximum constructive interference with the five-slit mask? Explain your reasoning.

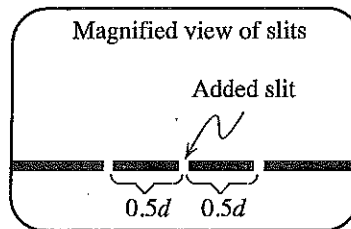
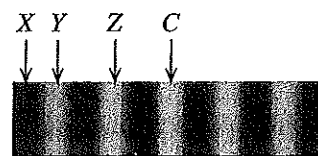
With the five-slit mask, how many minima would there be between each pair of principal maxima?

- iii. Would point Z still be a point of maximum constructive interference with the five-slit mask? Explain your reasoning.

- iv. If the distance between the centers of adjacent slits in the five-slit mask is 125λ , determine the angle (measured relative to the normal to the screen) to the minimum closest to the center of the screen. Show your work.

2. Consider the original double-slit pattern from problem 1, shown at right. Suppose that a third slit of the same width were added halfway between the original two slits as shown in the figure below the pattern. (Note that this results in the distance between adjacent slits becoming *half* of the original value.)

Pattern on screen with two slits

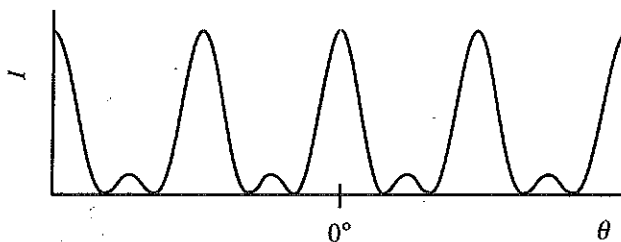


- a. Would point Z be a *principal maximum*, a *minimum*, or *neither*? Explain your reasoning.

- b. Would point Y be a *principal maximum*, a *minimum*, or *neither*? Explain your reasoning.

- c. Would point X be a *principal maximum*, a *minimum*, or *neither*? (Hint: Use superposition.) Explain your reasoning.

3. Monochromatic light from a distant point source passes through a mask containing an unknown number of slits. The graph of intensity *versus* angle is shown at right.

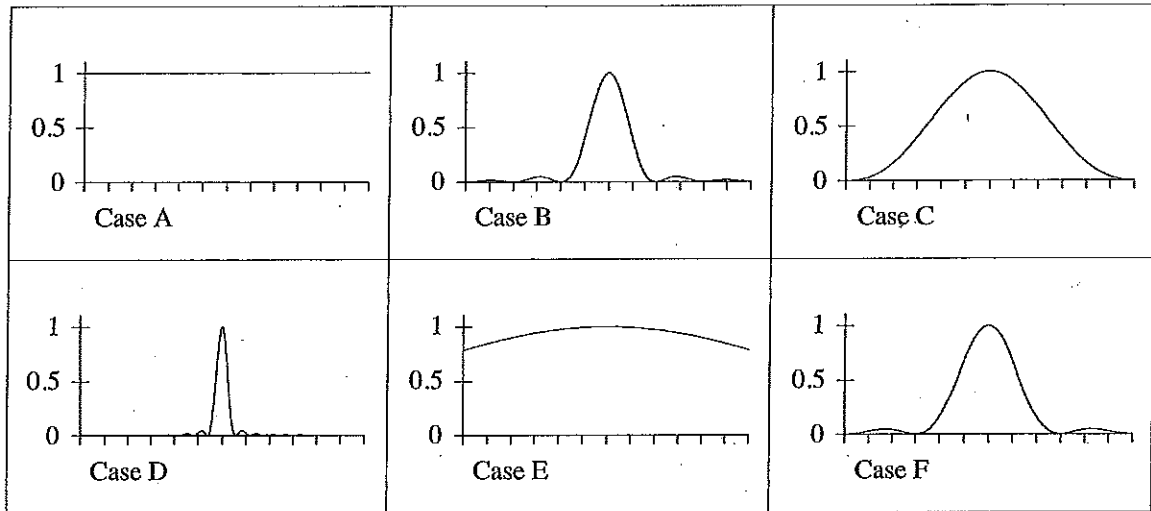


- a. How many slits were there in the mask? Explain how you can tell from the graph. (Hint: Base your answer on your results from section III of the tutorial "Multiple-slit interference.")

- b. Clearly label each of the minima and principal maxima with the corresponding value of ΔD_{adj} in terms of λ , where ΔD_{adj} is the difference in distances to adjacent slits.

1. Light from a distant point source is incident on a narrow slit. Each of the graphs below shows the intensity on a distant screen as a function of θ . The only difference among the six physical situations is the width of the slit.

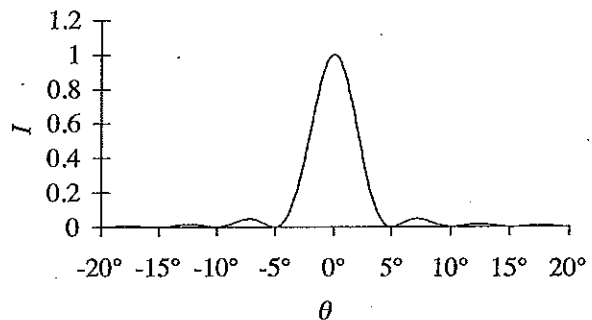
The horizontal scale is the same for all graphs. The vertical scale has been normalized so that the maximum intensity is the same for all cases.



Rank the cases according to the width of the slit, from largest to smallest. Explain your reasoning.

2. The graph at right shows the intensity on a distant screen as a function of θ for a single-slit experiment.

- a. Determine the width of the slit in terms of λ . Show your work.



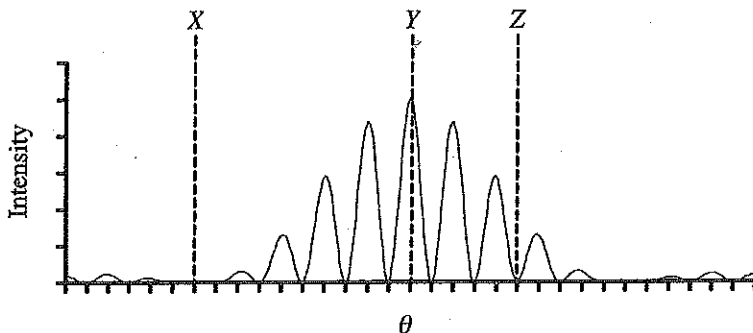
- b. If $\lambda = 580$ nm, what is the width of the slit in mm? Show your work.

COMBINED INTERFERENCE AND DIFFRACTION

Name _____

Optics
HW-155

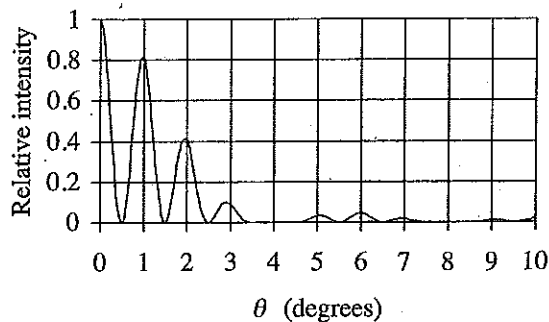
1. Monochromatic light from a distant point source is incident on two slits. The resulting graph of intensity versus θ is shown below. Point Y is the center of the screen; points X and Z are minima.



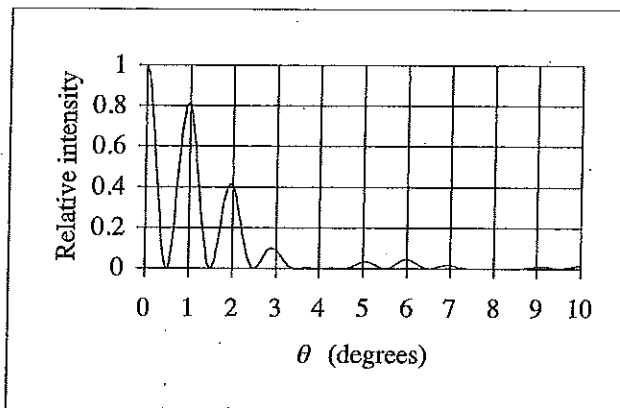
- a. If one of the slits in the mask were covered, would the intensity at each of the following points *increase*, *decrease*, or *stay the same*? Explain your reasoning in each case.
- point X
 - point Y
 - point Z
- b. Determine the ratio of the distance between the slits to the slit width, d/a , for this case. Explain your reasoning. (*Hint*: Can you identify any “missing” interference maxima?)

2. Light from a laser ($\lambda = 633 \text{ nm}$) is incident on two slits. The resulting graph of *relative intensity* versus θ is shown at right. (The center of the pattern is at $\theta = 0^\circ$.)

Calculate the slit width, a , and the distance between the slits, d . Make clear which features of the graph you use to answer.

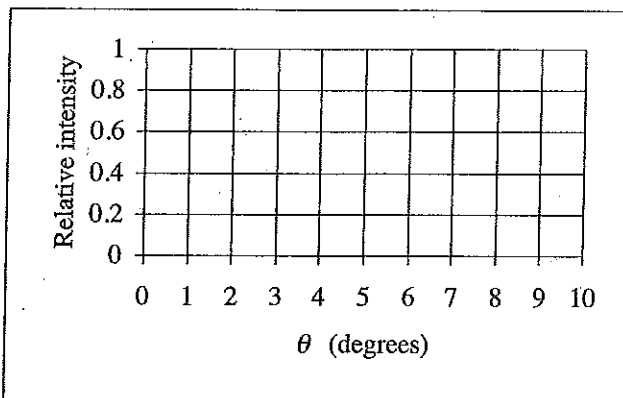


3. Monochromatic light from a distant point source is incident on two slits. The width of each slit is a and the distance between the centers of the slits is d . The resulting graph of *relative intensity* versus θ is shown at right. (The center of the pattern is at $\theta = 0^\circ$.)

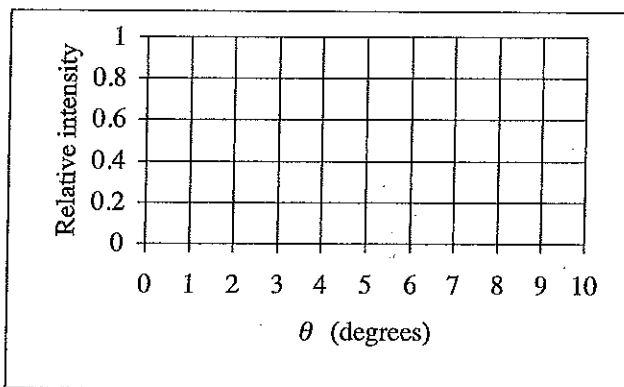


Sketch the relative intensity graph that would result when each of the following changes is made. Your graphs should show the approximate locations of the maxima and minima and be qualitatively correct as to the relative sizes of the maxima. *Explain your reasoning.*

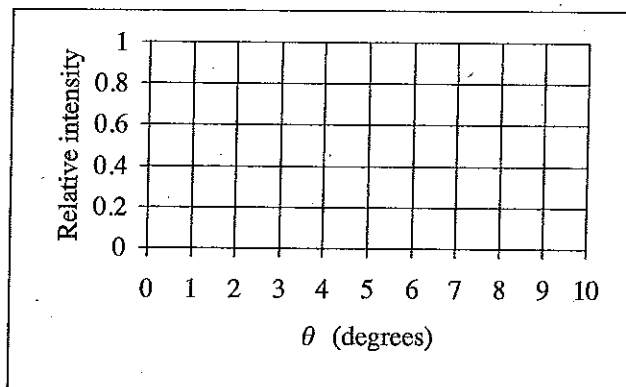
- a. The width of both slits is reduced to $a/2$, while keeping the spacing d fixed.



- b. The distance between the centers of the slits is reduced to $d/2$, while keeping the width of the slits (a) fixed.



- c. A third slit of width a is added to the right of the existing slits, while keeping the distance between adjacent slits (d) fixed.

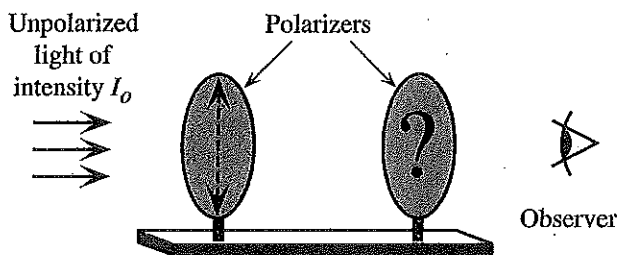


2. Unpolarized light of intensity I_0 is incident on a pair of (ideal) polarizers, as shown below. The direction of polarization of the first polarizer is vertical. The second polarizer has *unknown* orientation.

For each part below, determine whether it is possible for the light that reaches the observer to have the given value of intensity.

If so: Determine the direction of polarization of the second polarizer. Show all work.

If not: Explain why not.



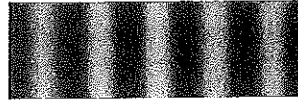
- a. No light reaches the observer.

- b. Light of intensity $2I_0/3$ reaches the observer.

- c. Light of intensity $I_0/2$ reaches the observer.

- d. Light of intensity $I_0/4$ reaches the observer.

3. Unpolarized red light is incident on two identical, narrow vertical slits. The photograph at right shows the interference pattern that appears on a distant screen.



Double-slit pattern produced by unpolarized red light

- a. Specify the quantity or quantities that are adding to zero at the interference minima. ("The light waves from the two slits are adding to zero" is *not* a sufficient answer.)
- b. A polarizer is placed directly in front of both slits, so that the light is *vertically* polarized before passing through the slits. It is observed that the intensity at each point on the screen decreases by a factor of two.

How can you account for the decrease in intensity at the interference maxima?

- c. The polarizer is slowly rotated through 360° . As the polarizer is rotated, it is observed that the interference pattern does not change.

Consider the following *incorrect* prediction:

"If the direction of polarization of the polarizer were horizontal, I don't think any light would reach the screen. In that case the light that reaches each slit would be polarized horizontally, so the light would be blocked by each of the vertical slits."

What is the flaw in the reasoning? Explain.

- d. Now imagine that one polarizer is placed in front of each slit: one polarizer with its direction of polarization vertical; the other, horizontal.

Would there still be locations on the screen at which the intensity is zero? Explain why or why not.