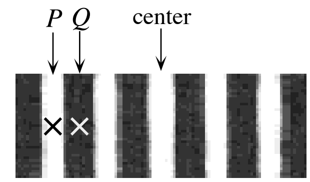
Name ____**Student ID** __________________ **Score**_______
last *first*

IV. [20 pts total] Parts A and B below are independent.

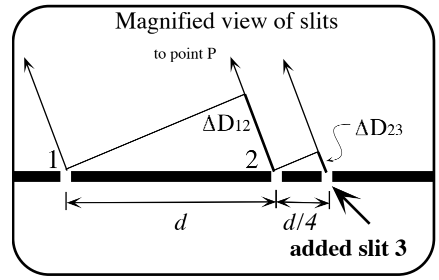
Pattern on distant screen



A. Coherent red light of wavelength λ is incident on a mask with two identical, very narrow slits separated by a distance d. The pattern at right is seen on a distant screen. Point P is a maximum; point Q, a minimum.

Suppose that a third slit were added to the mask a distance $d/4$ to the right of the original slits, as shown at right.

1. [5 pts] After the third slit is added, would the intensity at point P *increase, decrease,* or *stay the same?* Explain.



From similar triangles (see diagram), we can relate the path length difference for light traveling to point P from slits 2 and 3 (ΔD_{23}), and from slits 1 and 2 (ΔD_{12}):

$$\frac{\Delta D_{23}}{\Delta D_{12}} = \frac{d}{4}\Big/ d = \frac{1}{4} \quad\Rightarrow\quad \Delta D_{23} = \frac{1}{4}\Delta D_{12}.$$

For light traveling to point P from slits 1 and 2, the path length difference

$$\Delta D_{12} = 2\lambda \quad\Rightarrow\quad \Delta D_{23} = \frac{1}{4}\cdot 2\lambda = \frac{1}{2}\lambda.$$

At point P, light from slit 1 is in phase with light from slit 2. Since $\Delta D_{23} = \lambda/2$, light from slit 3 is π out of phase with light from both slits 1 and 2. Thus there is complete destructive interference between the light from slit 3 and the light from one of the original slits. As a result, only light from the other original slit contributes to the intensity at point P. Thus ***the intensity at point P decreases.***

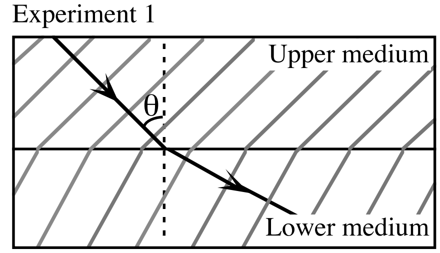
2. [5 pts] After the third slit is added, would the intensity at point Q *increase, decrease,* or *stay the same?* Explain.

At point Q, light from slit 1 is π out of phase with light from slit 2, leading to complete destructive interference at that point. When slit 3 is added, light from the slit leads to a non-zero intensity at point 3. Therefore, ***the intensity at point Q increases****.*

B. Shown at right is a ray diagram in Experiment 1 illustrating a periodic wave passing from one medium (upper medium) into another (lower medium).

A student is allowed to make changes to the upper medium only.
In Experiment 2, a student replaced the upper medium with a different medium causing the wavelength of the incident wave to change.

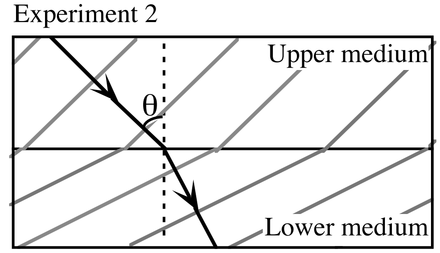
Experiment 1



1. [5 pts] Is the ray diagram at right drawn by the student in Experiment 2 consistent with the change? Explain.

The wavefronts in both media in Experiment 1 are shown in the diagram above right. Within each medium, the wavefronts are perpendicular to the ray and join at the boundary. In Experiment 2, the upper medium is replaced such that the wavelength is changed so we know the speed in that medium changed. Since neither the lower medium nor the wave frequency changed, the wavelength of the transmitted wave is the same in both experiments. The orientation of the wavefronts in Experiment 2, shown below right, ***is consistent with the change****.*

Experiment 2



2. [5 pts] Is the wavelength of the transmitted wave in the lower medium In Experiment 2 *greater than, less than* or *equal to* the wavelength of the transmitted wave in the lower medium in Experiment 1? Explain.

As stated above, neither the lower medium nor the frequency of the wave is changed. Thus, the wavelength of the transmitted wave is ***the same*** *in both experiments.*