**Assignment 4**

Wednesday, 26 September

*Reading:* Continue reading the material on classical waves in Halliday, Resnick, and Walker.

*Problems:* Due Wednesday, 3 October.

1. In his 1963 book *Strength to Love*, Dr. Martin Luther King, Jr. wrote that:

   Darkness cannot drive out darkness; only light can do that. Hate cannot drive out hate; only love can do that.

   We have seen in this course that light plus light might add up to darkness. Does this invalidate the first part of Dr. King’s metaphor?

2. *Fresnel interference.* Two narrow slits, illuminated by light of wavelength \( \lambda \), are separated by distance \( d = 3.00 \lambda \). Consider the light intensity along a line directly behind the top slit. (The dashed line in the figure below.) How far from the top slit is the farthest point of completely destructive interference?

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![Diagram of two parallel slits with light intensity profile]
3. Babinet’s principle. Light falls on a barrier which contains a big hole — so much bigger than the wavelength of the light that diffraction effects are negligible and geometric optics applies. Thus there’s brightness behind the hole but darkness everywhere else behind the barrier. Select some point $P$ within the shadow.

An obstacle such as $A$ is placed over the hole. Because obstacle $A$ has thin pieces, it diffracts light into the shadow, and there is now some light intensity at point $P$.

Obstacle $B$ is the photographic negative of obstacle $A$: it blocks light where $A$ passes light and passes light where $A$ blocks light. Because obstacle $B$ also has thin pieces, it too diffracts light into the shadow, and again there is some light intensity at point $P$.

Because obstacles $A$ and $B$ are complete opposites, you might expect that their diffraction patterns would be opposites also. This expectation is completely wrong: Show that the intensity at point $P$ is exactly the same whether obstacle $A$ or obstacle $B$ is used.

Hints: (a) Huygens’s Principle tells us that when the hole is unobstructed it acts as an infinite number of radiators, each sending waves in all directions, including the direction toward point $P$. Given that point $P$ receives light from an infinite number of sources, why is it dark there? (b) Use superposition. (c) The solution to this problem is much shorter than its statement.

Jacques Babinet (1794–1872) was French, so his name is pronounced “Ba-bi-nay.” His parents wanted him to become a magistrate, but instead he became a physics professor at age 26 and a member of the prestigious Académie des Sciences at age 46. He was an early proponent (after Young and Fresnel) of the wave theory of light, and the first scientist to use diffraction gratings for spectroscopy. He experimented on optical effects in mineralogy and meteorology (rainbows, coronas, and the polarization of skylight), and invented a goniometer and the “Babinet compensator,” which is still used today to produce and analyze polarized light. He achieved considerable fame as a popularizer of science.