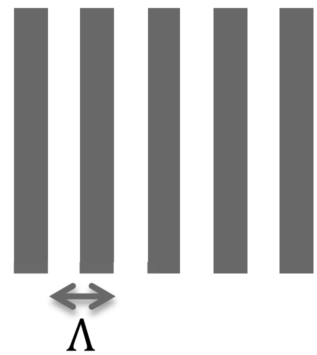
EE 134, Spring 2012, lecture 4: Motivation of wave optics

Materials needed: one-dimensional grating, 650 nm laser pointer, white LED, ruler, observation screen (can be sheet of graph paper)

Goals

- Explore the relationship between wave optics and ray optics, specifically phenomena that cannot be explained by ray optics.
- Use the conceptual ideas of wave optics to predict, observe, and measure interference effects.

Part I



Suppose you are given a one-dimensional grating with period Λ. A one-dimensional grating is a thin, flat object with alternating opaque and transparent parallel bars. Suppose your observation screen is placed some distance (~50 cm) behind the grating.

Predict what you will see on your observation screen if you shine a red light-emitting diode (LED) on the grating. Explain your reasoning by drawing a diagram showing how the light emitted from the LED travels to the observation screen.

Predict what you will see on your observation screen if you shine a red 650-nm laser on the grating. (A laser is different from an LED in that it generates coherent light; that is, the oscillation of the electromagnetic field in one part of the beam can be calculated by knowing the oscillation of another part of the beam. LEDs generate incoherent light; the oscillations of the electromagnetic field are random.) You may assume the laser beam is approximated by a plane wave incident on the grating. Explain your reasoning by drawing a diagram showing how the light emitted from the laser pointer travels to the observation screen.

Observe and draw what you see on your observation screen when you shine a single white LED on the grating. Record the distance between the grating and the observation screen, as well as the size of any features you see.

Observe and draw what you see on your observation screen when you shine a red 650-nm laser pointer on the grating. Record the distance between the grating and the observation screen, as well as the size of any features you see.

Hypothesize: What's going on?

Part II

Now that you have learned about the basic interference of waves, draw a schematic of how light travels from the laser pointer, through the grating, and onto the observation screen. You may assume the laser produces a beam with approximately planar wavefronts. Label relevant dimensions on your schematic that contribute to interference, such as distances, path lengths, separations, and angles. Write an equation that relates the deflection angle of each diffraction order to the wavelength of light and grating period. Assume $\Lambda \gg \lambda$.

From your observations in part I, deduce the frequency of the grating ($1/\Lambda$ in units if lines/mm) you were given.

Predict what you would see on your observation screen if you shined a green 532-nm laser on the grating. How will this be different from the pattern observed with the 650-nm laser? Label the size of any features you draw.