Intro:

We finish off the semester with diffraction and interference. From slits, to thin films, to interferometers these effects are the basis of many visually striking effects as well as high precision measurement.

Reading:

• HRW Chapter 35 all of the chapter
• HRW Chapter 36 only sections 1 through 6, plus the phasor work in class

Physics Topics:

• Multiple slit diffraction patterns
• Thin films
• Interferometers

Problems:

(1) In a double slit experiment a thin flake of mica \((n = 1.58)\) is placed over one slit. The slits are illuminated by 552 nm light. Comparing to the pattern before the mica was introduced, the location of the central maxima is now occupied by the seventh bright fringe. What is the thickness of the mica?

(2) A rhinestone is made from glass \((n = 1.521)\) coated with a thin layer of silicon monoxide \((n = 2.000)\). What is the minimum thickness of the coating needed to ensure that violet of wavelength 410.0 nm will be reflected with fully constructive interference?

(3) HRW 35.36
(4) HRW 35.55(a)
(5) HRW 36.4
(6) HRW 36.39

(7) The three slit pattern can be nicely modeled with three equal length phasors, one representing the wave from each slit. As you move along the screen the relative angle (the phase!) between the phasors changes. For instance, at the central maximum we have

\[
\text{with relative phase } \phi = 0.
\]

At a minimum we have this diagram

\[
\text{with relative phase } \phi = 2\pi/3.
\]

Notice that the phasors have the same relative angle (and phase) with their neighbor. In lab the last week of the semester you will find that there are two dark bands and one dim fringe between principal bright fringes. Explain this with a few sketches of phasors and a brief explanation.

(8) Double Slit Redux: In 1905 Einstein suggested that light comes in discrete packages or particles, now called “photons”, each with energy \(E = hf\), where \(h\) is Planck’s constant. This model prompted several investigators to try preserving the older wave picture by proposing modifications of classical theory. J. J. Thomson suggested that electromagnetic energy might
be “clumped” together across the wave front. This hypothesis led to the suggestion that at very low intensities, ordinary diffraction patterns might be modified in some way. G. I. Taylor undertook an experimental study of this. Using a very low intensity light (reduced using a slit and smoked glass screens) photographs were taken of an interference pattern. The longest exposure was 2000 hours. (Rumor has it that Taylor, an avid sailor, went off sailing for this 3 month period.) The intensity was $3.45 \times 10^{-13}\text{Js}^{-1}\text{m}^{-2}$.

(a) Taking the energy of one photon to be $2\text{ eV}$, show that the intensity corresponds to about 100 photons per second per cm$^2$ ($1\text{ eV} = 1.6 \times 10^{-19} \text{ J}$). This intensity implies an average distance of separation of about 300 m. So with an apparatus of about a meter, it is extremely unlikely that more than one photon would have been present in the system at the same time!

(b) For a double slit experiment, what do you infer from the fact that Taylor observed the usual double slit interference pattern under extremely weak illumination?

(9) **Bonus** In the soap film demo explain why the top section of the soap film appears dark just before it breaks. Estimate the thickness of this top section of the soap film at this moment.

And that is it. Thanks for a great semester!