HW 14 Due anytime Friday 5/6

For this week you should read Ch. 27, sections1, 2, 3, 7, 8, 10, 11, and 12.

1) This problem is easier than it looks. For this problem assume that the wavelengths of the three primary colors are λ_{red} = 650 nm, λ_{green} = 550 nm , λ_{blue} = 450 nm.

Recall from lecture or from section 24-2 in your textbook that when light travels from one medium to another its frequency remains constant but its speed and hence its wavelength changes. Also recall that your eye responds to frequency rather than wavelength because the cells in your retina respond to how quickly the electric field is oscillating (the frequency), and they have no way of judging the distance between crests (the wavelength). Together these two facts explain, why a blue swimsuit looks blue even under water. The first fact is needed for part b) of this problem.

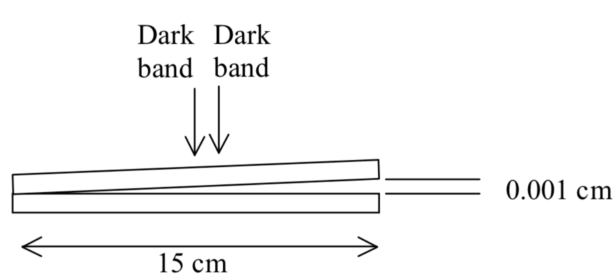
a) Consider the soap film I showed you in class on Friday that was illuminated with white light. (See photo on Physerver). Near the top of the film there is a yellow band. At this location, one of the three primary colors is not reflected because the film is just the right thickness to lead to destructive interference for that color. The other two colors are reflected, at least partially, leading to the yellow band? Which color is not reflected?

b) What is the wavelength of the color that is not reflected, in the film? Assume the film is water. See eq. 24-1

c) In order for no light to be reflected, the thickness of the film must be ¼ λ, ¾ λ, ... where λ is the wavelength in the film. The film is thinnest at the top, so suppose that at the first yellow band the thickness is ¼ λ. What is the thickness in mm? Wow that is thin!

d) The next color below yellow is magenta. What is the thickness of the film there? Hint: First figure out what color is not reflected, then proceed as in c).

2) In class I demonstrated thin film interference using an arrangement similar to the one shown in Figure 24-33. In the demonstration, the plates were clamped at one end, but unlike in Fig. 24-33 there was no wire at the other end. After class I carefully measured the thickness of the two plates at each end and determined that the air gap between the plates had a thickness of about 0.01 mm at the unclamped end.



a) If the plates are 15 cm long, what is roughly the angle between the plates in degrees?

b) Suppose that the plates are illuminated with yellow light with a wavelength of 589 nm, producing a series of light and dark bands along the entire length of the plates. Two *adjacent* dark bands are indicated in the figure. At the dark band on the left, the light reflected from the top of the bottom plate is out of phase with the light reflected from the bottom of the top plate. At the band on the right the two reflected beams are again out of phase, because the light reflecting off the top of the bottom plate will have traveled an extra wavelength through the thicker air gap. How much thicker is the air gap at the band on the right compared to the gap at the band on the left?

c) Given the angle you calculated in a) what is the distance measured along the plate between the centers of the two dark bands? From seeing the demo you should have some idea if your answer is reasonable.

3) Ch.24 Question 29

4) Explain the dark patch in the upper left hand corner of Figure 24-44 on p. 686.

5) Make a reasonable estimate for the wavelength of green light and then determine the energy of a green photon. Compare to the kinetic energy of an electron accelerated in an electron gun by a potential difference of 150 V. Based on this comparison, you should see that the electrons involved in the e/m lab we did back in March had more than enough energy to cause the helium atoms to emit the green light we observed in that experiment.

6) What is the energy of a x-ray photon if the wavelength of the x-ray is 0.1 nm? Compare to the energy of a green photon.

7) The red lasers we have been using in lab have a power output of about 1 mW at a wavelength of 633 nm. How many photons does the laser produce per second?

8) It is said that on a clear moonless night in North Dakota a person can see a candle from a distance of 5 km. Suppose that the power output of a candle is about 0.003 watts in the visible part of the spectrum.

a) What is the intensity of the light in watts/m^2 at a distance of 5 km from the candle? Assume that the light from the candle spreads out evenly in all directions.

b) When fully dark-adapted, the pupil of the human eye has a radius of about 0.5 cm. What is the area of the pupil in m^2?

c) If a person is 5 km from this candle, how many joules of light energy enter the person's eye per second?

d) Assuming that the candle light is yellow (on average) how many photons enter the person's eye per second? Use $\lambda_{yellow} = 590$ nm

9) Ch. 27 P21

10) Ch. 27 P24

11) Determine the wavelength of light emitted when the electron in a hydrogen atom moves from

a) n = 3 to n = 2
b) n = 7 to n = 2
c) n = 50 to n = 2
d) n = 2 to n = 1
e) n = 50 to n = 3

For each wavelength indicate the color or region of the spectrum.

12) Determine the radius of the orbit of an electron in a hydrogen atom in an n = 1, an n=2, and an n = 3 orbit. What are the ratios of the radii?