

# Chapter 24 'Spring Break' Extra Credit: Homework Answers and Hints

The following pages include answers to the HW problems, general problem-solving hints for thin film problems, and specific hints on the assigned problems. Use them after completing the reading and studying the example problems in the textbook, while you are attempting to complete the HW problems.

**Good luck!**

## E.C. HW Answers

These are just the problems omitted from your in-class assignment, which means the answers are on the original assignment/answers sheet you were given. But in case you crossed 'em out or lost that paper...

39. 643nm

44.  $9.045E^{-6}$  m

41. 169nm

45. Bright: 112.5nm

42. 228nm

Dark: 225nm

43.  $8.53E^{-6}$  m

## General Hints

The example on page 682 is the best 'simple' example of how to do these problems. But here's some general advice of how to think while doing these problems...

The main idea during problem-solving is that you've got to consider the difference in path lengths for two different waves that interfere constructively: one reflects off of the front surface of a thin film, and one travels through the film, reflects off the back surface, and travels back through the film.

Continued on Next Page

## General Hints (cont.)

These two waves will only interfere constructively if there's no phase-difference between them (meaning that a crest travels along with another crest). This would happen for an easy situation if the second wave travels through the film, and in doing so travels exactly one wavelength farther than the first wave. In this situation, it would make sense to set up an equation like this,  $2t = \lambda$ , where  $t$  refers to the film's thickness. The reason for  $2t$  is because the second wave travels back and forth through the film.

Continued on Next Page

## General Hints (cont.)

But there are two more things to consider when trying to use an equation like what we just set up. The first is that the  $\lambda$  you use in the equation must be the wave's  $\lambda$  while it's actually in the film. And we know, from other ideas in Unit 11, that  $\lambda$  decreases when light passes from air into anything else. So the  $\lambda$  you should actually use is  $\lambda_{\text{substance}} = \lambda_{\text{air}} / n_{\text{substance}}$  .

Continued on Next Page

## General Hints (cont.)

The other thing you must consider when trying to use our kind of equation is that waves sometimes invert upon striking a boundary. (Picture a pulse sent down a string fixed at one end. When the pulse bounces back, it will be flipped over.) The general rule to remember for light wave reflections is that the wave does invert by  $180^\circ$  upon reflection from a boundary if it tries to pass into a substance with a higher n-value. If both boundaries lead to inversions, you really don't need to worry about it at all.

Continued on Next Page

## General Hints (cont.)

But if the wave only inverts at one boundary, then our previous equation must account for the fact that the second wave has already essentially 'travelled'  $\frac{1}{2}\lambda$  farther than the reflected/inverted wave, simply by the fact that this second wave won't ever invert. So this changes the format of the equation to something like this,  $2t = \frac{1}{2}\lambda_{\text{substance}}$ , for situations where only one inversion takes place.

Don't try to memorize formulas, as much as learn *why* the process works. Then the problems really aren't too hard.

## Ch 24 #39

This one's very similar to the example on Pg. 682, with the exception that now you're told the thickness and you're being asked to find the  $\lambda$ . It should be pretty straightforward, as long as you think about the inversion that occurs at the front surface and the lack of inversion at the rear surface.

Also remember that the  $\lambda$  you'll solve for in your equation will be  $\lambda_{\text{substance}}$ . But the problem wants to know the  $\lambda$  that is seen in the air, so you'll have to finish the problem with a quick multiplication by  $n_{\text{substance}}$ .

## Ch 24 #41

The difference between this one and the example on Pg. 682 is that you're now being asked for the thickness that "would appear black if illuminated". This means that you're looking for a thickness that leads to destructive interference, rather than the constructive interference you're thinking about in most of these problems.

## Ch 24 #42

If this film appears greenish yellow, then that must be the wavelength that corresponds to constructive interference for this film. Make sure you think about whether inversion is occurring at the front and rear surfaces, and remember that if inversion occurs in both places, you don't really need to consider it in your equation.

## More General Hints

These “Newton’s Rings” kind of problems are a little different, because they usually have to do with a number of rings or lines that occur for a film of air that has different thickness at different points along it. For these problems, you should follow the example on page 681, where they really just thought about the thickest part of the air film. At this thickest part, the difference in the path lengths between the two waves has to do with the number of lines seen.

Continued on Next Page

## More General Hints (cont.)

You need to think about whether you're dealing with constructive or destructive interference (bright or dark lines), and you also still need to think about whether each wave inverts during reflection, with the same rule we've been using. You don't however, need to consider any changes in  $\lambda$  because the film itself is made out of air.

## Ch 24 #43

For this problem you're being asked for thickness at a location where the light travels through enough path difference (plus inversion stuff) to see the 31<sup>st</sup> dark line. The first wave reflects (no inversion) from the front surface of the air film, and the second wave travels through  $2t$  and arrives back at the front surface having traveled  $31\lambda$  farther than the first wave. This means that destructive interference will occur (when you remember the 2<sup>nd</sup> wave was inverted upon its reflection at the rear surface of the film) for the 31<sup>st</sup> time at the lens edge.

## Ch 24 #44

This one should feel just like #43, and also VERY similar to the example on Pg. 681. You're finding the thickness at a location where the second wave travels far enough during its  $2t$  extra path length for it to interfere destructively (after inverting at the rear surface of the air film), for the 27<sup>th</sup> time.

## Ch 24 #45

This one is actually more similar to the earlier problems like #41-42, but with an air film instead of soap or some other substance. You don't need to think about number of lines or rings, but instead can go back to thinking just about *minimum* thickness for either constructive (part A) or destructive (part B) to occur.