

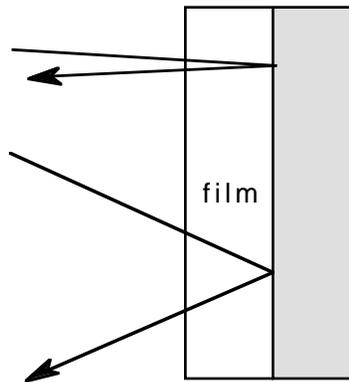
THIN FILMS PROBLEMS

More difficult problems are indicated with an asterisk.

1. What are the thickness and index of the thinnest anti-reflective coating for a lens of index 1.69 for light of 530 nanometers?
- 2.* For a particular material, the minimum thickness of the anti-reflective coating which produces maximum attenuation of light of 550 nm wavelength occurs when the coating is 75 nm thick. What other thicknesses will produce equal attenuation?
- 3.* An anti-reflective coating is placed on a lens so as to minimize reflection of 550 nm light. What will the color of the coating be when light is reflected from it? Will it appear to have the same color when viewed normally as when viewed from oblique angles?
4. Collimated monochromatic light normally incident on a pair of glass plates separated by a spacer produces fringes 0.50 mm wide. When an unknown fluid flows between the plates, the fringes are 0.36 mm wide. What is the optical index of the fluid?
5. Will the fringes in Newton's rings be separated more at the center or at the edge of the pattern? Why?
- 6.* What is the amplitude condition for an anti-reflective coating of index n' placed on a lens material of index n if the lens is immersed in a fluid of index n_o ?
- 7.* Newton's rings are formed by shining a laser downward on a lens in air. The lens is made of plastic of index 1.4. When the lens is gently lowered into a viscous fluid, the bright rings of the pattern become dark and the dark rings become bright. The contrast in the pattern is unaltered. What is the index of the viscous fluid? Explain the change in appearance of the interference pattern.

ANSWERS

1. index 1.30; thickness $102 \text{ nm} = 1.02 \times 10^{-4} \text{ mm}$.
2. The thickness of an AR coating is $t = (\lambda/4n)(1+2m)$. For minimum thickness, $m=0$ and $\lambda/4n = 75 \text{ nm}$. Other thicknesses that will work are $3 \times 75 \text{ nm} = 225 \text{ nm}$, $5 \times 75 \text{ nm} = 375 \text{ nm}$, etc.
3. Since 550 nm light is yellow, the AR coating will not be as effective with long wavelength and short wavelength light. These reds and blues will combine to produce a magenta color for light incident normally. As the diagram shows, the optical pathlength for oblique light travelling through the film is longer than for normal light, so for obliquely incident and reflected light, longer wavelength reflections will be cancelled out and the AR coating will appear blue, green, yellow, etc., depending on the angle.



4. 1.39
5. center
6. This could be derived from basic principles, but it is easier to re-interpret the indices in the usual amplitude condition in air as relative indices so $n \rightarrow n/n_0$ and $n' \rightarrow n'/n_0$, and $n = \sqrt{n_0 n}$ to $n = \sqrt{(n_0 n)}$.
7. The effect occurs if the interface at the back of the lens surface goes from dense to rare to rare to dense. This takes place if the fluid has index greater than the lens. Since the contrast remains the same, the amount of light reflected at the back surface would be the same as the front, hence the index would be $n = 1.42 = 1.96$. In practice, of course, such a high index would be impossible to achieve in a fluid, but any value of $n > 1.4$ would reverse the bright and dark fringes, though with reduced contrast. (Why?)