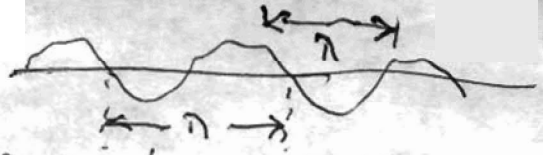
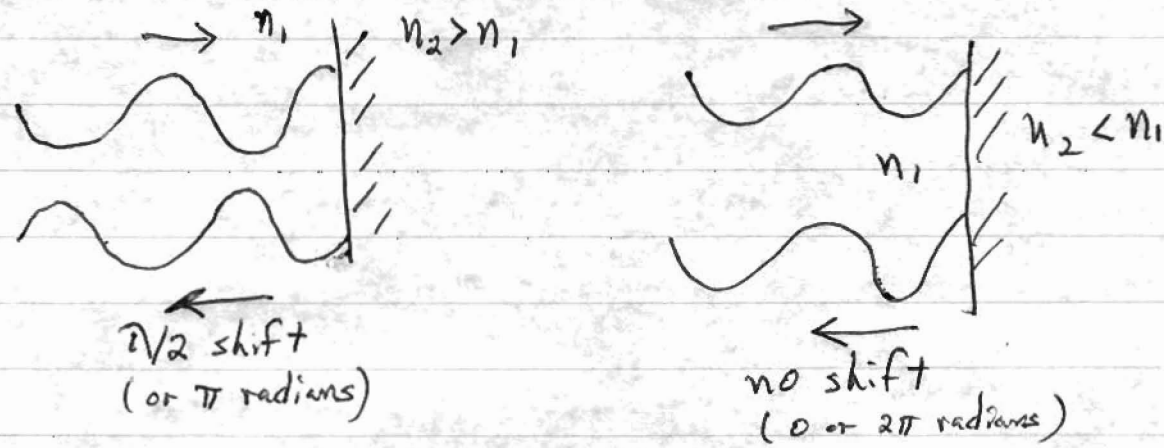


Reflection off surface layers



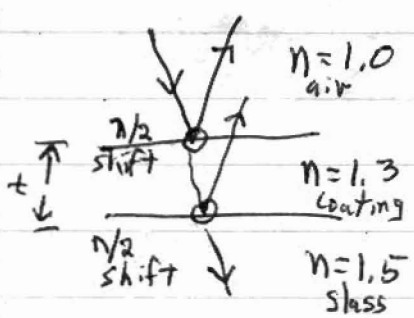
Thin films

$f\lambda = v = \frac{c}{n}$

$f\lambda = c$ (air)

∴ λ in medium n, remember f is constant

$\lambda_n = \frac{\lambda_{air}}{n}$

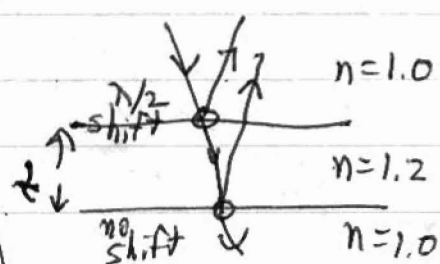


Max reflection (constructive)
Min transmission
(sun coatings on windows)

$2t = m\lambda_n = m\frac{\lambda}{1.3}$

Min reflection (destructive)
Max transmission
(B-2's, telescopes)

$2t = (m+\frac{1}{2})\lambda_n = (m+\frac{1}{2})\frac{\lambda}{1.3}$



Soap bubble

Bright reflection (constructive)

$2t = (m+\frac{1}{2})\frac{\lambda}{n} = (m+\frac{1}{2})\frac{\lambda}{1.2}$

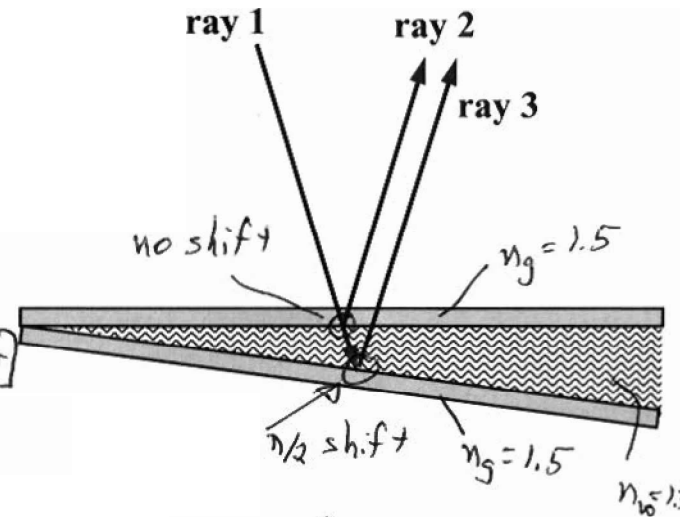
Dark reflection
Max transmission

$2t = m\frac{\lambda}{n} = m\frac{\lambda}{1.2}$

Physics 24 Test-Level Problems for Recitation 29

B 1. Two identical microscopic slides in air illuminated with light from a laser are creating an interference pattern. The space between the slides is now filled with water (n=1.33). What happens to the interference fringes?

[A] They are spaced farther apart.
[B] They are spaced closer together.
[C] There is no change.
[D] Not enough information is provided to give an answer.

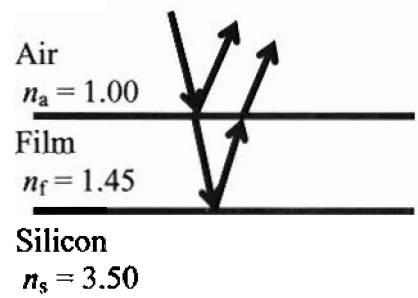


Constructive $2t = (m + \frac{1}{2})\frac{\lambda_0}{1.33}$ [water]

$2t = (m + \frac{1}{2})\lambda_0$ [air]

∴ In H_2O more m's / thickness ∴ lines closer together

2. A thin film of transparent material ($n_f = 1.45$) is placed on a silicon solar cell ($n_S = 3.50$) in order to minimize reflection losses. The cell is illuminated from above by normally incident sunlight.



(a) Does the light reflected from the ***top*** surface of the film undergo a phase change upon reflection? Yes

(b) Does the light reflected from the ***bottom*** surface of the film undergo a phase change upon reflection? Yes

(c) What is the minimum thickness of the film that results in minimizing the reflection of 550 nm light?

Want Destructive interference

$$2t = (m + \tfrac{1}{2})\lambda_f$$

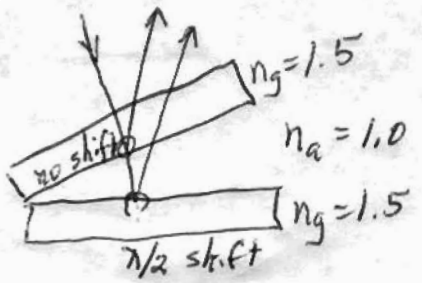
$$t = \frac{\lambda_0}{4\lambda_f} = \frac{550\,nm}{4(1.45)} = \boxed{94.8\,nm}$$

Section 35.4 Interference in Thin Films

35.27 Two rectangular pieces of plane glass are laid one upon the other on a table. A thin strip of paper is placed between them at one edge so that a very thin wedge of air is formed. The plates are illuminated at normal incidence by 546-nm light from a mercury-vapor lamp. Interference fringes are formed, with 15.0 fringes per centimeter. Find the angle of the wedge.

Constructive interference

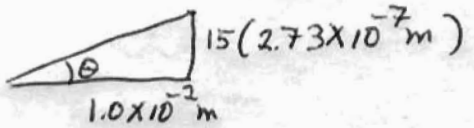
$2t = (m + 1/2)\lambda_n$; $\lambda_n = \frac{\lambda_0}{1.0}$



Thickness between two fringes

$2t = \lambda_0$

$t = \frac{546 \times 10^{-9}\,m}{2} = 2.73 \times 10^{-7}\,m$

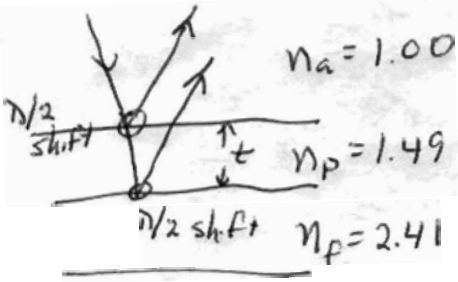


$\tan\theta = \frac{15(2.73 \times 10^{-7}\,m)}{1.00 \times 10^{-2}\,m}$

$\theta = 0.0235^\circ$

35.30 A thin film of polystyrene is used as a nonreflecting coating for fabulite (see Table 33.1). What is the minimum thickness of the film required? Assume that the wavelength of the light in air is 480 nm.

Constructive Interference



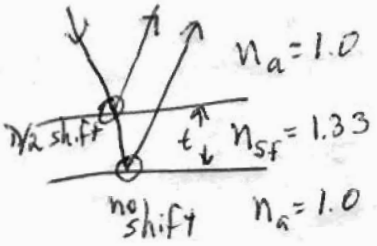
$2t = (m + 1/2)\lambda_n$

$2t = \frac{1}{2}\frac{\lambda_0}{1.49}$

$t = \frac{480 \times 10^{-9}\,m}{4(1.49)} = \boxed{80.5 \times 10^{-9}\,m = 80.5\,nm}$

35.34 What is the thinnest soap film (excluding the case of zero thickness) that appears black when illuminated with light with wavelength 480 nm? The index of refraction of the film is 1.33, and there is air on both sides of the film.

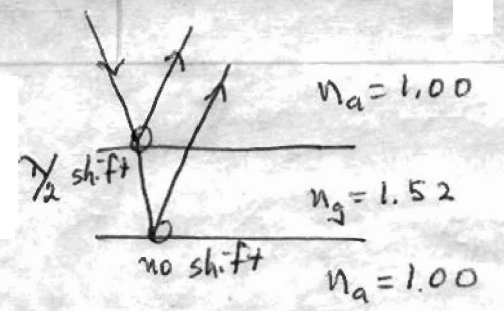
Destructive Interference



$2t = \lambda_{sf} = \frac{\lambda_0}{1.33}$

$t = \frac{480 \times 10^{-9}\,m}{2(1.33)} = \boxed{1.80 \times 10^{-7}\,m = 180\,nm}$

35.52 White light reflects at normal incidence from the top and bottom surface of a glass plate ($n = 1.52$). There is air above and below the plate. Constructive interference is observed for light whose wavelength in air is 477.0 nm. What is the thickness of the plate if the next longer wavelength for which there is constructive interference is 540.6 nm?



$$2t = (m + \tfrac{1}{2})\lambda_g$$

$$2t = (m + \tfrac{1}{2})\frac{\lambda_0}{1.52} \Rightarrow \lambda_0 = \frac{2(1.52)t}{(m+\tfrac{1}{2})} \quad \text{or} \quad 3.04t = (m + \tfrac{1}{2})\lambda_0$$

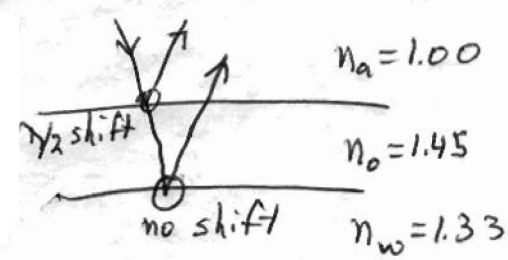
$$3.04t = (m+\tfrac{1}{2})(477\,nm) = (m - \tfrac{1}{2})(540.6\,nm)$$

$$477m + 238.5 = 540.6m - 270.3$$

$$63.6m = 508.8 \Rightarrow m = 8$$

$$t = \frac{(8.5)(477\,nm)}{3.04} = 1{,}334\,nm$$

35.56 An oil tanker spills a large amount of oil ($n = 1.45$) into the sea ($n = 1.33$). a) If you look down onto the oil spill from overhead, what predominant wavelength of light do you see at a point where the oil is 380 nm thick? What color is the light? (*Hint:* See Table 32.1.) b) In the water under the slick, what visible wavelength (as measured in air) is predominant in the transmitted light at the same place in the slick as in part (a)?



a) Constructive Interference

$$2t = (m + \tfrac{1}{2})\frac{\lambda_0}{1.45} \Rightarrow \lambda_0 = \frac{(2.90)(380\,nm)}{m+\tfrac{1}{2}} = \frac{1{,}102\,nm}{m+\tfrac{1}{2}}$$

$m = 0 \quad \lambda_0 = 2{,}204\,nm$

$m = 1 \quad \lambda_0 = 735\,nm$ IR

$\boxed{m = 2 \quad \lambda_0 = 441\,nm \text{ Blue}}$

$m = 3 \quad \lambda_0 = 315\,nm$ UV

b) Destructive Interence

$$2t = m\frac{\lambda_0}{1.45}$$

$$\lambda_0 = \frac{(2.90)(380\,nm)}{m} = \frac{1{,}102\,nm}{m}$$

$m = 1 \quad \lambda_0 = 1{,}102\,nm$ IR

$\boxed{m = 2 \quad \lambda_0 = 551\,nm \text{ Green}}$

$m = 3 \quad \lambda_0 = 367\,nm$ UV