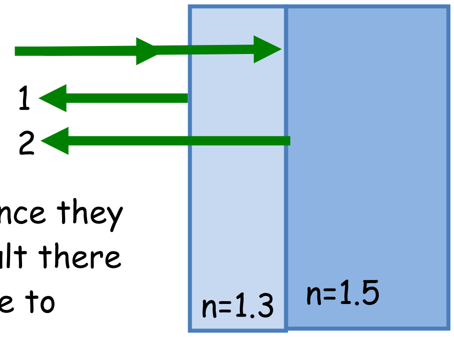
Diffraction and Interference Worksheet — College Physics 104

1. A transparent film (n=1.3) is deposited on a glass lens (n=1.5) to form a nonreflective coating. What is the smallest film thickness that would minimize reflection of light with a wavelength of 500 nm in air.



To minimize reflection, we want destructive interference

$$\Delta d + \phi = (m + \tfrac{1}{2})\lambda_{film}$$

Both rays 1 and 2 undergo a $\lambda/2$ phase shift since they both reflect from low to high index. As a result there is no phase DIFFERENCE between the rays due to reflection so $\phi=0$

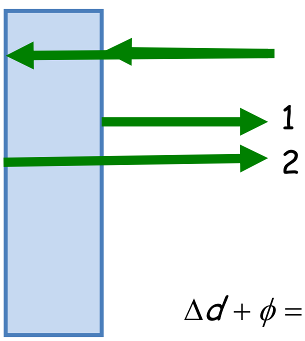
$$\Delta d + \phi = (m + \tfrac{1}{2})\lambda_{film} = 2t$$

m=0 gives minimum thickness

$$t = \frac{\lambda_{film}}{4} = \frac{\lambda_0}{4n_{film}} = \frac{500nm}{4(1.3)} = 0.96nm$$

2. A 910nm soap film in air has an index of refraction of n=1.46. (a) Which visible wavelengths are weakest in reflected light? B) Which visible wavelengths are strongest in reflected light? (HINT: try various values of m until you find wavelengths between 400nm and 700 nm)

a)



To minimize reflection, we want destructive interference

$$\Delta d + \phi = (m + \tfrac{1}{2})\lambda_{film}$$

Ray 1 undergoes a $\lambda/2$ phase shift since it reflects from low to high index. Ray 2 has no phase shift on reflection.

$$\Delta d + \phi = (m + \tfrac{1}{2})\lambda_{film} = 2t + \frac{\lambda}{2} \qquad m\lambda_{film} = 2t = m\frac{\lambda_0}{n_{film}}$$

m	λ_0 (nm)
1	2657
2	1329
3	886
4	664
5	531
6	443
7	380

$$\lambda_0 = 2tn_{film} / m = 2(910nm)(1.46) / m = 2657\,nm / m$$

λ_0 = 664 nm, 531 nm, and 443 nm

b) For constructive interference we have

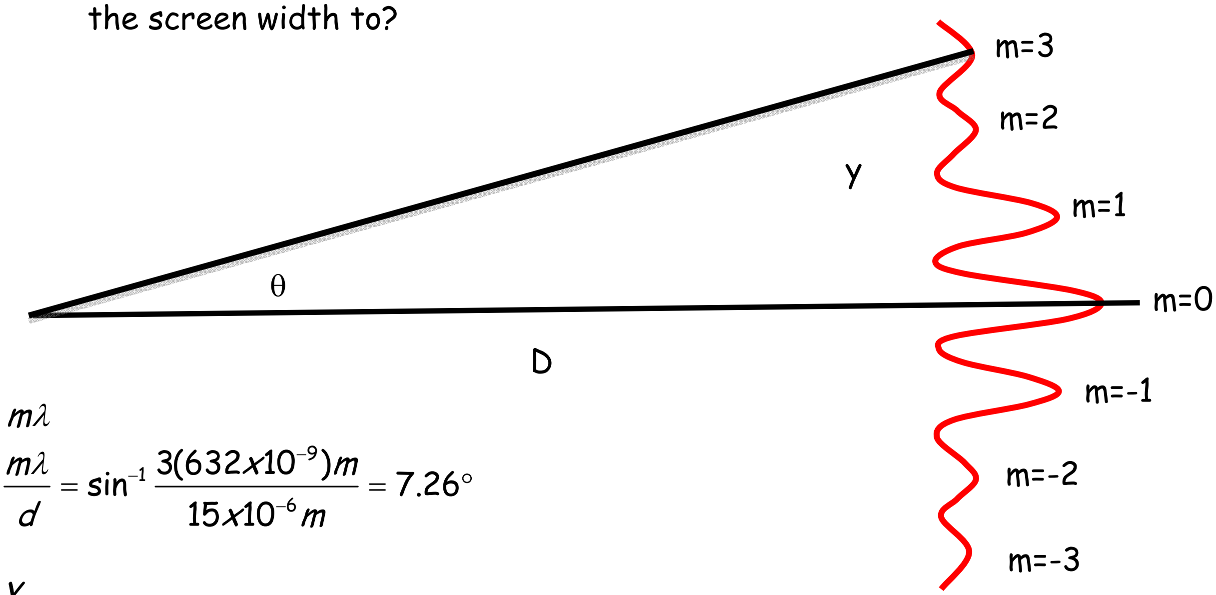
$$\Delta d + \phi = 2t + \frac{\lambda}{2} = m\lambda_{film} \qquad 2t = (m - \tfrac{1}{2})\lambda_{film} = (m - \tfrac{1}{2})\lambda_0 / n$$

$$\lambda_0 = 2tn_{film} / (m - \tfrac{1}{2}) = 2(910nm)(1.46) / (m - \tfrac{1}{2}) = 2657\,nm / (m - \tfrac{1}{2})$$

m	λ_0 (nm)
1	5314
2	1771
3	1063
4	929
5	590
6	483
7	409

λ_0 = 590 nm, 483 nm, and 409 nm

3. You have a coherent light source with a wavelength of 632 nm. You send the light through a double slit with slit separation of 15μm to a screen located 1.2m away.
    a) if you want to see at least 7 interference maxima, how wide should your screen be?
    b) How many maxima will you see if you change the wavelength to a blue light of 410nm? (remember m must be an integer)
    c) If you wanted to see just 7 blue maxima, what should you change the screen width to?



a)

$$d\sin\theta = m\lambda$$

$$\theta = \sin^{-1}\frac{m\lambda}{d} = \sin^{-1}\frac{3(632x10^{-9})m}{15x10^{-6}m} = 7.26^{\circ}$$

$$\tan\theta = \frac{y}{D}$$

$$y = D\tan\theta = 1.2m\tan(7.26^{\circ}) = 0.153m$$

screen width = 2y= 0.306m

b) $m\lambda = d\sin\theta$

$$m = \frac{d\sin\theta}{\lambda} = \frac{15x10^{-6}m\sin(7.26)}{410x10^{-9}m} = 4.62$$

since m must be an integer, the largest value of m is 4, so we will see 9 maxima.

C) $d\sin\theta = m\lambda$

$$\theta = \sin^{-1}\frac{m\lambda}{d} = \sin^{-1}\frac{3(410x10^{-9})m}{15x10^{-6}m} = 4.7^{\circ}$$

$$\tan\theta = \frac{y}{D}$$

$$y = D\tan\theta = 1.2m\tan(4.7^{\circ}) = 0.099m$$

screen width = 2y= 0.198m