

(1) A material having an index of refraction of 1.20 is used to coat a piece of glass ( $n=1.60$ ). What is the minimum film thickness to minimize reflected light of 470 nm? What is the minimum film thickness to maximize reflected light of 470 nm?

(2) A soap film ( $n=1.3$ ) has a thickness of 800 nm. What wavelengths of visible light will be reflected?

(3) A thin layer of liquid with  $n=1.8$  is between two slides of glass ( $n=1.5$ ). What is the minimum thickness of this film if light with  $\lambda=600$  nm is to be reflected?

(4) A laser beam ( $\lambda=600$  nm) is incident upon two slits  $0.2 \times 10^{-3}$  m apart. How far will the bright interference lines be on a screen 10 m from the slits?

(5) Suppose the slits in Young's experiment are  $0.15 \times 10^{-3}$  m apart and when the pattern shines on a screen 1.0 m away, the third bright band is  $10.0 \times 10^{-3}$  m away from the central maximum. What is the wavelength of the light?

(1) A material having an index of refraction of 1.20 is used to coat a piece of glass ( $n=1.60$ ). What is the minimum film thickness to minimize reflected light of 470 nm? What is the minimum film thickness to maximize reflected light of 470 nm?

Solution: This material is assumed to be in air. Ray  $r_1$  If we order to indices of refraction then we have  $n_1 < n_2$  and  $n_2 < n_3$ . This corresponds to case 2 in the notes:

**Constructive** :  $2n_2t = m\lambda$  for  $m = \{1, 2, 3, \dots\}$

**Destructive** :  $2n_2t = (m + \frac{1}{2})\lambda$  for  $m = \{0, 1, 2, 3, \dots\}$

To **minimize** reflected light , we require

$$t = \frac{(m + \frac{1}{2})\lambda}{2n_2} .$$

The minimum thickness where this occurs is for  $m=0$ . Thus

$$t_{\min} = \frac{\lambda}{4n_2} = \frac{470\text{nm}}{4 \times 1.20} = \mathbf{97.9\text{nm}}$$

To maximize the reflected light, we need the condition for constructive interference:

$$t = \frac{m\lambda}{2n_2}$$

The minimum thickness will happen for  $m=1$  here. Thus

$$t_{\min} = \frac{1 \times \lambda}{2 \times n_2} = \frac{470}{2 \times 1.20} = \mathbf{195.8\text{nm}}$$

(2) A soap film ( $n=1.3$ ) has a thickness of 800 nm. What wavelengths of visible light will be reflected?

Solution: this condition corresponds to case 1 where

**Constructive** :  $2n_2t = (m + \frac{1}{2})\lambda$  for  $m = \{0, 1, 2, 3, \dots\}$

Let's look for wavelengths between 700 and 400 nm. Solving this condition gives:

$2080 = (m + 1/2)\lambda \Rightarrow \lambda = 2080 / (m + 1/2)$  We thus have the following cases:

M	$\lambda$
0	4160
1	1387
2	832
3	594
4	462
5	378

Of these, only 594 nm and 462 nm lie in the required range ( $m=3$ ,  $m=4$ ).

(3) A thin layer of liquid with  $n=1.8$  is between two slides of glass ( $n=1.5$ ). What is the minimum thickness of this film if light with  $\lambda=600$  nm is to be reflected?

Solution: this corresponds to case 1 with constructive interference:

$$\text{Constructive : } 2n_2t = (m + \frac{1}{2})\lambda \text{ for } m = \{0,1,2,3,\dots\}$$

We can solve for this thickness:

$$t_{\min} = \frac{\lambda}{4n} = \frac{600}{2 \times 3.6} = 83\text{nm}$$

(4) A laser beam ( $\lambda=600$  nm) is incident upon two slits  $0.2 \times 10^{-3}$  m apart. How far will the bright interference lines be on a screen 10 m from the slits?

Solution: From the notes,

$$\text{Constructive : } \delta = m\lambda \{m = 0, \pm 1, \pm 2 \dots\}$$

$$\text{band positions: } Y = \frac{m\lambda L}{d}$$

We need to find  $\Delta Y$  which is the separation between any two bright bands. This is given by

$$\Delta Y = \frac{(m+1)\lambda L}{d} - \frac{m\lambda L}{d} = \frac{\lambda L}{d}$$

$$\Delta Y = \frac{600 \times 10^{-9} \times 10}{0.2 \times 10^{-3}} = 3 \times 10^{-2} \text{m}$$

(5) Suppose the slits in Young's experiment are  $0.15 \times 10^{-3}$  m apart and when the pattern shines on a screen 1.0 m away, the third bright band is  $10.0 \times 10^{-3}$  m away from the central maximum. What is the wavelength of the light?

Solution: From the notes,

$$\text{Constructive : } \delta = m\lambda \{m = 0, \pm 1, \pm 2 \dots\}$$

$$\text{band positions: } Y = \frac{m\lambda L}{d}$$

Here,  $m=3$ ,  $Y_3 = 10 \times 10^{-3}$ ,  $L=1.0$ , and  $d=0.15 \times 10^{-3}$ . So

$$\lambda = \frac{Yd}{3L} = \frac{10 \times 10^{-3} \times 0.15 \times 10^{-3}}{3 \times 1.0} \Rightarrow \lambda = 500\text{nm}$$