

(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 on top of a slide 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 0.2×10^{-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 0.15×10^{-3} m apart and when the pattern shines on a screen 1.0 m away, the third bright band is 10.0×10^{-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 r1 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: $2n_2t = \left(m + \frac{1}{2}\right)\lambda$ for $m = \{0, 1, 2, 3, \dots\}$

To **minimize** reflected light, we require

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

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

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

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

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

(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: $2n_2t = \left(m + \frac{1}{2}\right)\lambda$ 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	λ
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 on top of a slide 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 2 with constructive interference:

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

We can solve for this thickness:

$$t_{\min} = \frac{\lambda}{4n} = \frac{600}{4 \times 1.8} = 83 \text{ nm}$$

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

Solution: From the notes,

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

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

We need to find ΔY which is the separation between any two bright bands. This is given by

$$\begin{aligned} \Delta Y &= \frac{(m+1)\lambda L}{d} - \frac{m\lambda L}{d} = \frac{\lambda L}{d} \\ \Delta Y &= \frac{600 \times 10^{-9} \times 10}{0.2 \times 10^{-3}} = 3 \times 10^{-2} \text{ m} \end{aligned}$$

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

Solution: From the notes,

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

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

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

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