| | Physics 250: Worksheet 24 | Name: ________________ |
|---|---|---|

(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?

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(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 n1<n2 and n2<n3. This corresponds to case 2 in the notes:

$$\text{Constructive}: 2n_2t = m\lambda \text{ for } m = \{1,2,3,...\}$$

$$\text{Destructive}: 2n_2t = (m+\tfrac{1}{2})\lambda \text{ for } m = \{0,1,2,3,...\}$$

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

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

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

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

(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

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

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 λ=600 nm is to be reflected?

Solution: this corresponds to case 1 with constructive interference:

$$\text{Constructive}: 2n_2 t = (m+\tfrac{1}{2})\lambda \text{ for } m = \{0,1,2,3,\ldots\}$$

We can solve for this thickness:

$$t_{min} = \frac{\lambda}{4n} = \frac{600}{2x3.6} = 83\text{nm}$$

(4) A laser beam (λ=600 nm) is incident upon two slits 0.2 $x10^{-3}$ m apart. How far will the bright interference lines be on a screen 10 m from the slits?
Solution: From the notes,

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

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

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

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

$$\Delta Y = \frac{600x10^{-9}x10}{0.2x10^{-3}} = 3x10^{-2}\text{m}$$

(5) Suppose the slits in Young's experiment are $0.15x10^{-3}$ m apart and when the pattern shines on a screen 1.0 m away, the third bright band is $10.0x10^{-3}$ m away from the central maximum. What is the wavelength of the light?
Solution: From the notes,

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

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

Here, m=3, $Y_3 = 10x10^{-3}$, L=1.0, and $d=0.15x10^{-3}$. So

$$\lambda = \frac{Yd}{3L} = \frac{10x10^{-3}x0.15x10^{-3}}{3x1.0} \Rightarrow \lambda = 500\text{nm}$$