2016	Physics 220: 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 on top of a slide of glass (n=1.5). What is the minimum thickness of this film if light with λ=600 nm is to be reflected?

(4) A laser beam (λ=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 0.15×10^{-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?

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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:

Constructive: $2n_2 t = m\lambda$ for $m=\{1,2,3,\ldots\}$

Destructive: $2n_2 t = \left(m+\frac{1}{2}\right)\lambda$ for $m = \{0,1,2,3,\ldots\}$

To **minimize** reflected light , we require

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

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

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

(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

Constructive: $2n_2 t = \left(m+\frac{1}{2}\right)\lambda$ for m = $\{0,1,2,3,\ldots\}$.

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 λ=600 nm is to be reflected?

Solution: this corresponds to case 2 with constructive interference:

$$\text{Constructive}: 2n_2 t = \left(m + \frac{1}{2}\right)\lambda \text{ for m = \{ 0,1,2,3,... \}} \quad .$$

We can solve for this thickness:

$$t_{min} = \frac{\lambda}{4n} = \frac{600}{4x1.8} = 83\,nm$$

(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

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

$$\Delta Y = \frac{600 \, x \, 10^{-9} x \, 10}{0.2 \, x \, 10^{-3}} = 3x10^{-2} m$$

(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

$$\lambda = \frac{Yd}{3L} = \frac{10x10^{-3} x \, 0.15 \, x \, 10^{-3}}{3x1.0} \Rightarrow \lambda = 500\,nm$$