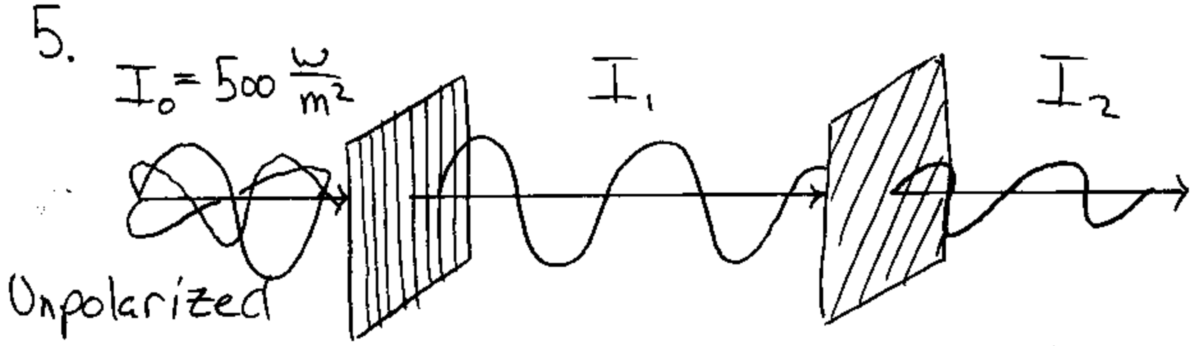
5.



Because incident light is unpolarized on the first polarizer. | $I_1 = \frac{1}{2} I_0$

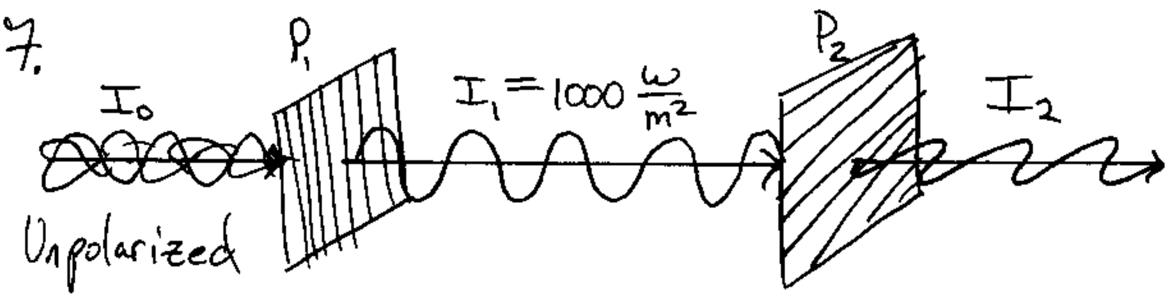
Second polarizer is 30° off the transmission axis of the first polarizer | $I_2 = I_1 \cos^2 30°$

$$\rightarrow I_2 = \left(\tfrac{1}{2} I_0\right)\cos^2 30° = \left(\tfrac{1}{2}\right)\left(500 \tfrac{W}{m^2}\right)\left(\tfrac{\sqrt{3}}{2}\right)^2$$

$$= \frac{3}{8} \cdot 500 \frac{W}{m^2}$$

$$= 187.5 \frac{W}{m^2}$$

7.



Transmission axes of P_1 & P_2 are 60° apart | $I_2 = I_1 \cos^2 60°$

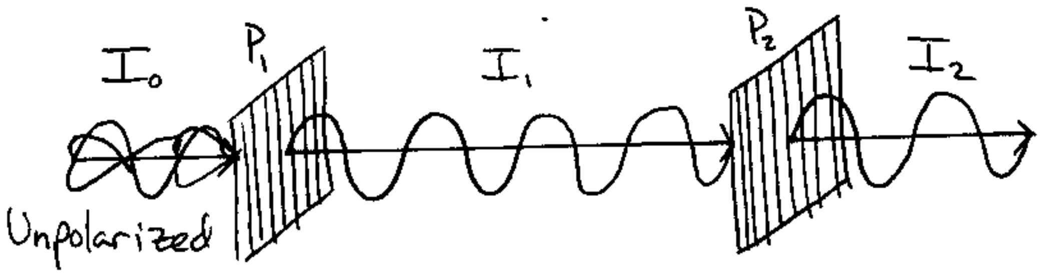
7. cont.

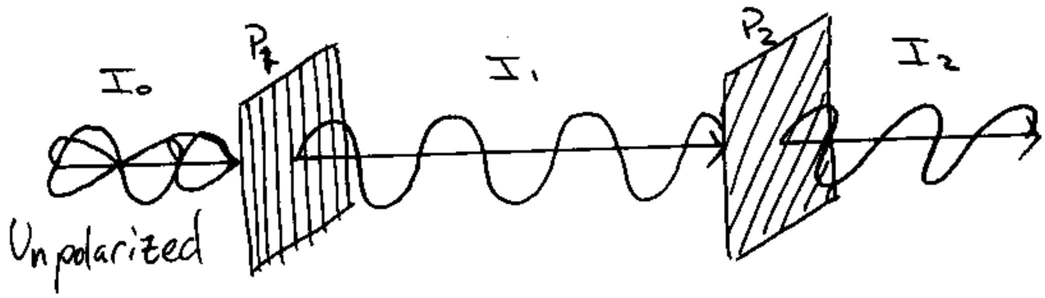
$$I_2 = 1000\,\frac{W}{m^2}\cos^2 60 = 1000\,\frac{W}{m^2}\left(\frac{1}{2}\right)^2$$
$$= 250\,\frac{W}{m^2}$$

Light incident on P_1 is unpolarized | $I_1 = \frac{1}{2} I_0$

$$I_0 = 2 I_1 = 2\left(1000\,\frac{W}{m^2}\right)$$
$$= 2000\,\frac{W}{m^2}$$

13.

① 

② 

① for ①, unpolarized light incident on P_1. | $I_1 = \frac{1}{2} I_0$

Transmission axes of P_1 and P_2 are parallel or 0° apart | $I_2 = I_1 \cos^2 0^\circ$

13. cont.

1 $\therefore\ I_2 = \left(\frac{1}{2}I_0\right)\cos^2 0^\circ = \left(\frac{1}{2}I_0\right)(1)^2$

$= \frac{1}{2}I_0$

3 for 2, unpolarized light incident on P_1 | $I_1 = \frac{1}{2}I_0$

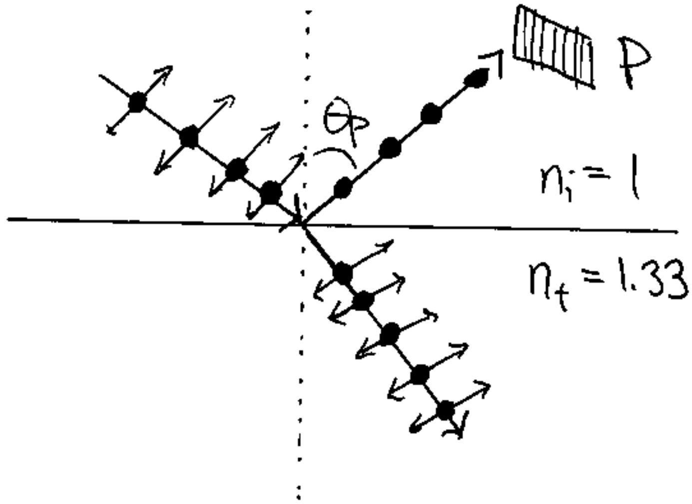
Transmission axes of P_1 and P_2 are 30° apart. | $I_2 = I_1\cos^2 30^\circ$

$\Longrightarrow I_2 = \left(\frac{1}{2}I_0\right)\cos^2 30^\circ = \left(\frac{1}{2}I_0\right)\left(\frac{\sqrt{3}}{2}\right)^2$

$= \left(\frac{1}{2}\right)\left(\frac{3}{4}\right)I_0 = \frac{3}{8}I_0$

ratio of $\frac{I_2\,②}{I_2\,①} = \frac{\frac{3}{8}I_0}{\frac{1}{2}I_0} = \boxed{\frac{3}{4}}$

19.

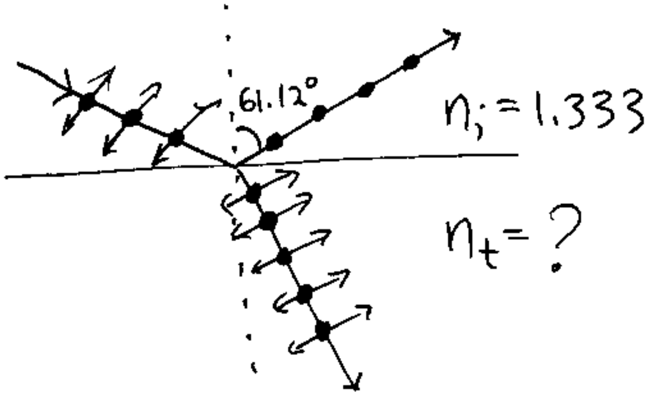


The only way the polaroid filter can absorb all the incident light and transmit nothing is when the incident light is completely linear polarized at 90° to the transmission axis of the filter. The only time that the reflected ray is linear polarized is at Brewster's angle where the reflected ray is linear polarized perpendicular to the plane of incidence. In this case a filter positioned with its transmission axis parallel to the plane of incidence would let none of the reflected ray pass.

$$\tan\theta_p = \frac{n_t}{n_i}$$

$$\theta_p = \arctan\left(\frac{1.33}{1}\right) = 53^\circ$$

24.



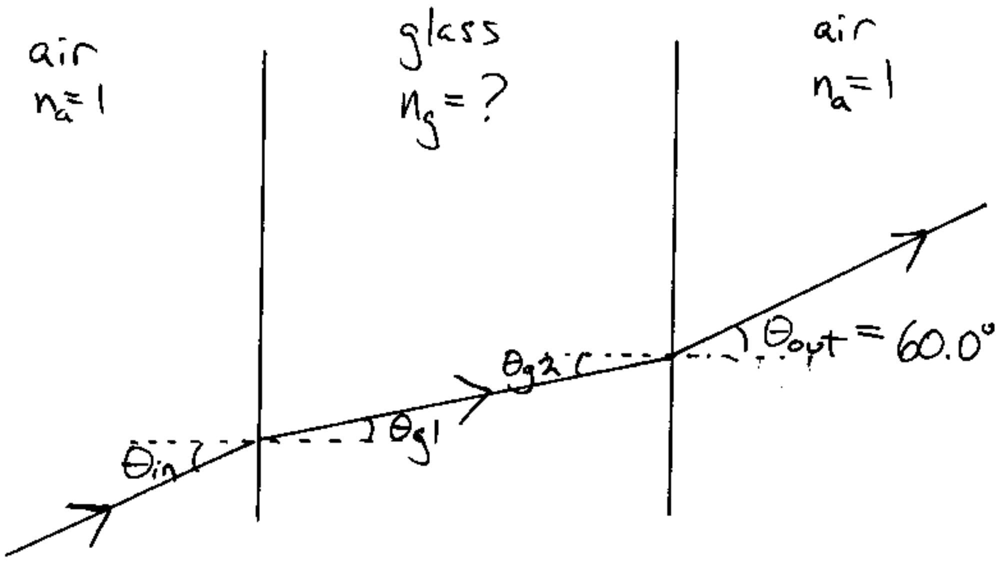
from Table: Diamond = 2.42

Since the reflected ray is completely polarized at 61.12°, this must be Brewster's angle.

$$\tan\theta_p = \frac{n_t}{n_i} \rightarrow n_t = n_i \tan\theta_p$$
$$= 1.333 \tan 61.12^\circ$$
$$= (1.333)(1.813)$$
$$= 2.417$$

Yes it is a diamond.

31.



Snell's Law | $n_a \sin\theta_{out} = n_g \sin\theta_{g2}$

31. cont.

By geometry (two parallel lines cut by a transverse have equal alternate interior angles): $\theta_{g1} = \theta_{g2}$

$$\longrightarrow n_g \sin\theta_{g2} = n_g \sin\theta_{g1}$$

but $n_g \sin\theta_{g1} = n_a \sin\theta_{in}$

$$\therefore n_a \sin\theta_{in} = n_a \sin\theta_{out}$$

$$\Longrightarrow \theta_{in} = \theta_{out} = 60.0^\circ$$

The fact that the light intensity leaving the glass is greatest means that the light energy lost to reflection, and consequently carried off through the incident side, is a minimum. This occurs at Brewster's angle because only light polarized $\perp$ to the plane of incidence can be reflected and lost.

$$\therefore \tan\theta_p = \frac{n_g}{n_a} \Longrightarrow n_g = (1)\tan 60^\circ$$

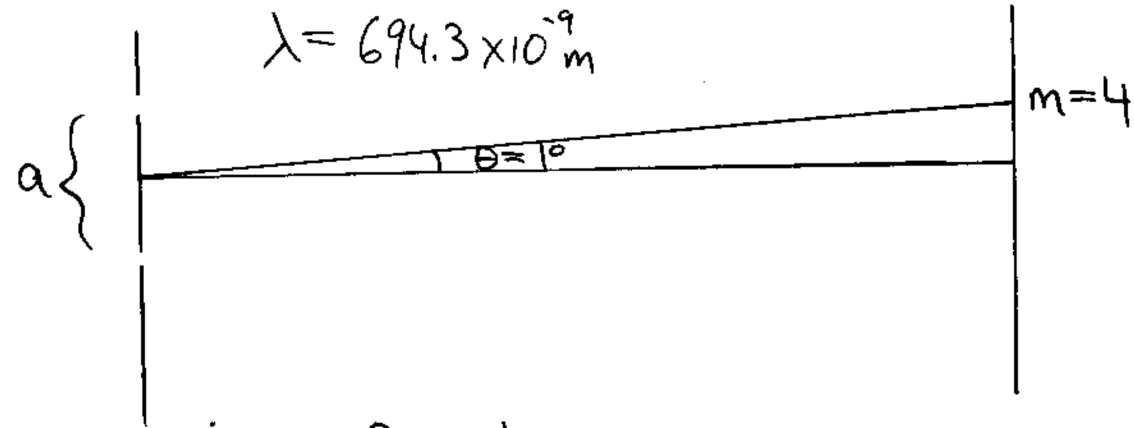
$$= \boxed{1.73}$$

$$n_a \sin\theta_{in} = n_g \sin\theta_g \Longrightarrow \sin\theta_g = \frac{n_a \sin\theta_{in}}{n_g}$$

$$\theta_{glass} = \arcsin\left(\frac{(1)(\sin 60^\circ)}{1.73}\right)$$

$$= \boxed{30^\circ}$$

34.



$$a \sin\theta = m\lambda$$

$$a = \frac{4(694.3 \times 10^{-9})}{\sin 1°}$$

$$= 1.59 \times 10^{-4}\,m$$

37. Same diagram as 34.

$a = 0.100\,mm = 1.00 \times 10^{-4}\,m$

$m = 5$

$\theta = 1.20°$

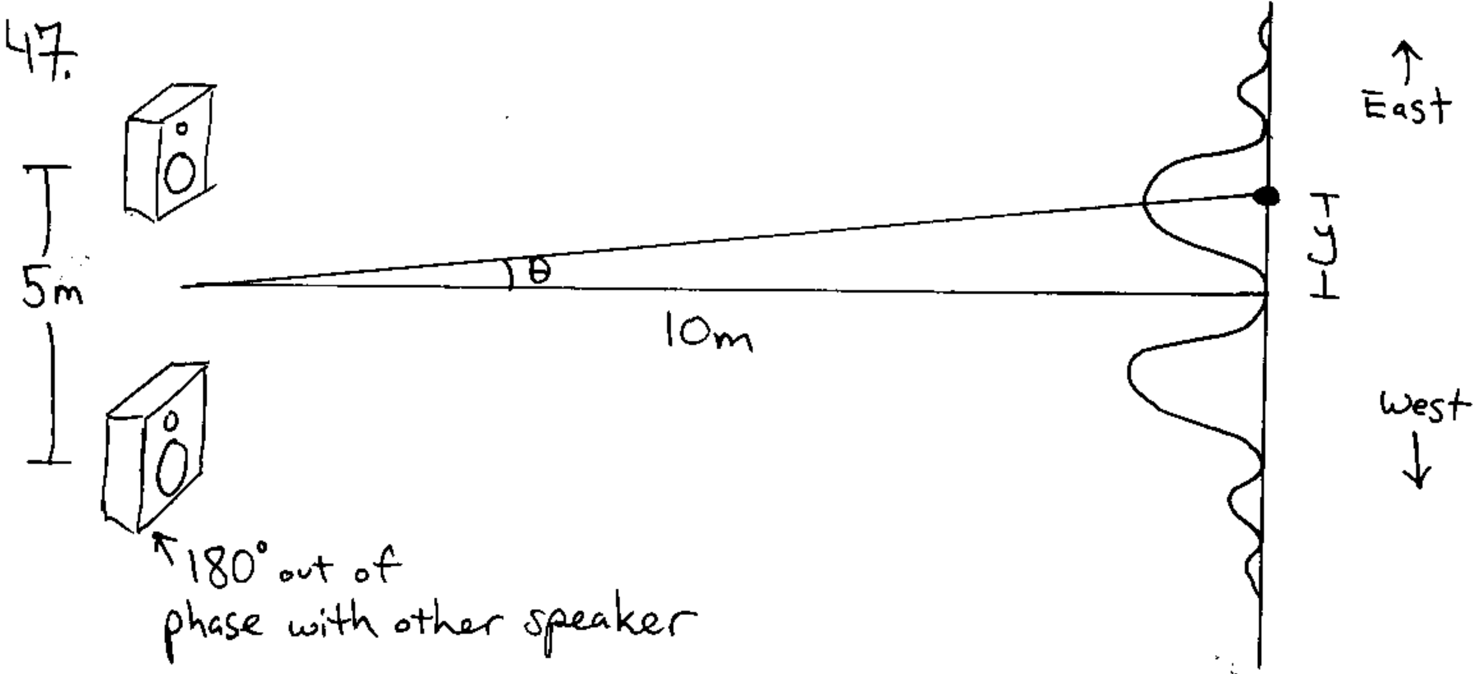
$$a \sin\theta = m\lambda$$

$$\lambda = \frac{a \sin\theta}{m} = \frac{(1.00 \times 10^{-4})(\sin 1.20°)}{5}$$

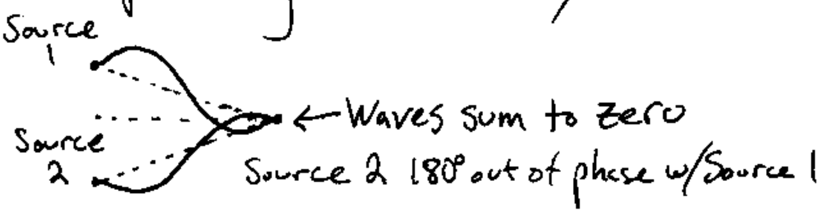
$$= 4.19 \times 10^{-7}\,m$$

or 419 nm

47.



The key to solving this problem is understanding that because the two speakers are 180° out of phase means that points equidistant from the speakers interfere destructively corresponding to intensity minima.



The intensity pattern, shown against the wall, is switched from the normal interference pattern such that maxima now correspond to minima.

— The main disadvantage to someone sitting on the midway line between the speakers is that they are listening from an intensity minima.

$\therefore$ $a\sin\theta = m\lambda$: Minimum b/c 180° out of phase

$a\sin\theta = (m+\frac{1}{2})\lambda$: Maximum

47. cont.

$f = 1000\,Hz \qquad v = 346\,\frac{m}{s}$

$$f\lambda = v$$

$$\lambda = \frac{v}{f} = \frac{346\ m/s}{1000\ 1/s} = .346\,m$$

first intensity peak @ $m=0$

$$\Rightarrow a\sin\theta = (0+\tfrac{1}{2})\lambda$$

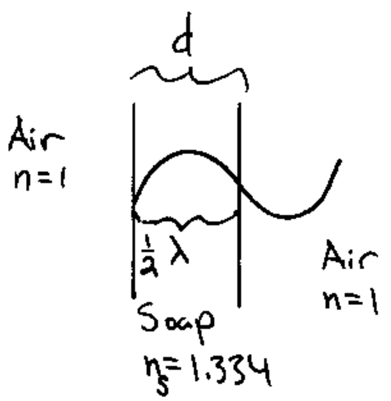
$$\theta = \arcsin\left(\frac{\frac{1}{2}\lambda}{a}\right)$$

$$= \arcsin\left[\frac{(\frac{1}{2})(.346m)}{5m}\right] = 1.983^\circ$$

$$\tan\theta = \frac{y}{10m} \Rightarrow y = 10m(\tan 1.983^\circ)$$

$$= \boxed{.346\,m}$$ how far east she needs to move to be in 1ST Maxima

50.



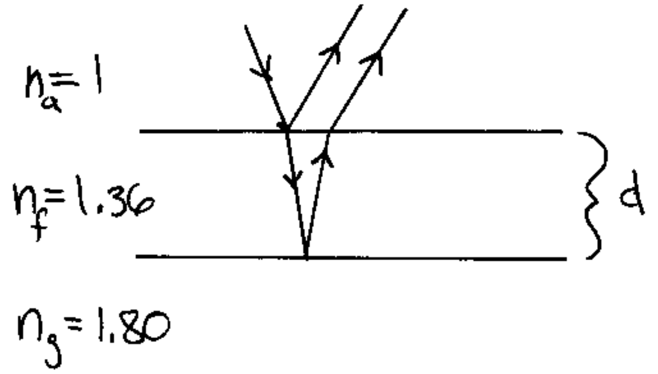
$$d = \frac{1}{2}\lambda = \frac{1}{2}\frac{\lambda_0}{n_s}$$

$$= \frac{1}{2}\ \frac{700\times10^{-9}m}{1.334}$$

$$= 2.62\times10^{-7}m$$

or 262 nm

53.



$\lambda_o = 560 \times 10^{-9} m$

For the film to appear green, we want the green reflected and refracted rays to interfere constructively; which means the extra distance traveled by the refracted ray needs to equal an integer number of wavelengths.

Since $n_a < n_f < n_g$, both rays undergo 180° phase shifts, effectively keeping them in phase.

$\therefore \quad 2d = m\lambda$ minimum thickness $\Rightarrow m = 1$

$$2d = \lambda = \frac{\lambda_o}{n_f}$$

$$d = \frac{\lambda_o}{2n_f} = \frac{560 \times 10^{-9} m}{2(1.36)} = 2.06 \times 10^{-7} m$$

or 206 nm

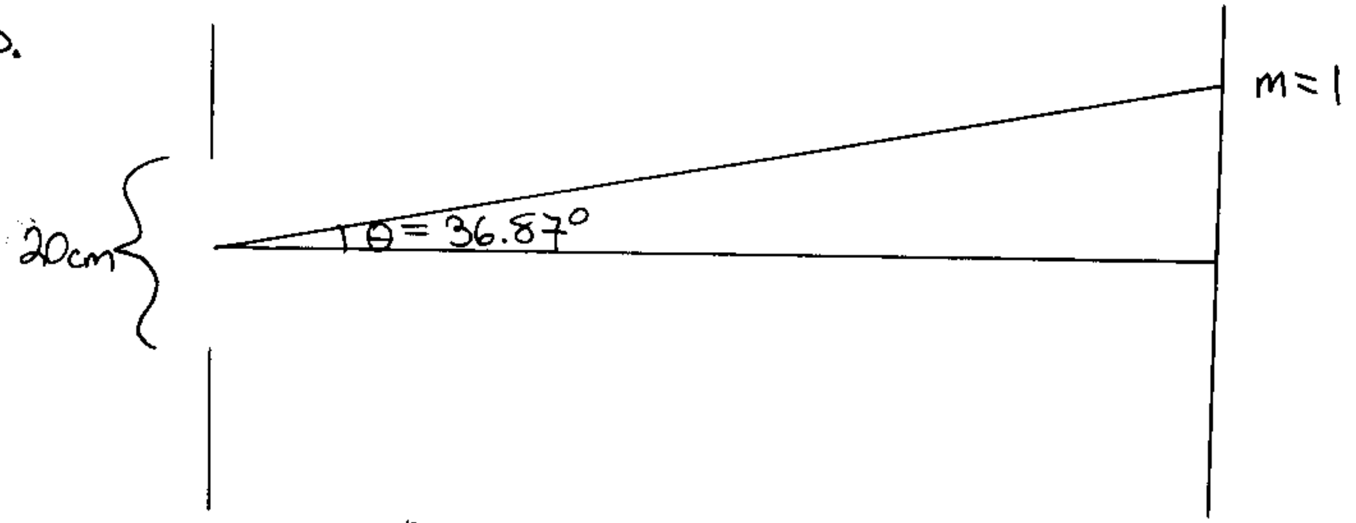
56. Same diagram as 53 with $n_a = 1$, $n_f = 1.30$, $n_g = 1.55$ & $\lambda_o = 500 nm$

In this case we want to decrease reflection of green light which means we want the 2 rays to interfere destructively. This corresponds to the refracted ray traveling an extra half wavelength.

$\therefore \quad 2d = (m + \frac{1}{2})\lambda$ minimum thickness $\Rightarrow m = 0$

$$d = \frac{1}{4}\lambda = \frac{1}{4}\frac{\lambda_o}{n_f} = \left(\frac{1}{4}\right)\left(\frac{500 \times 10^{-9} m}{1.30}\right) = 9.62 \times 10^{-8} m$$

73.

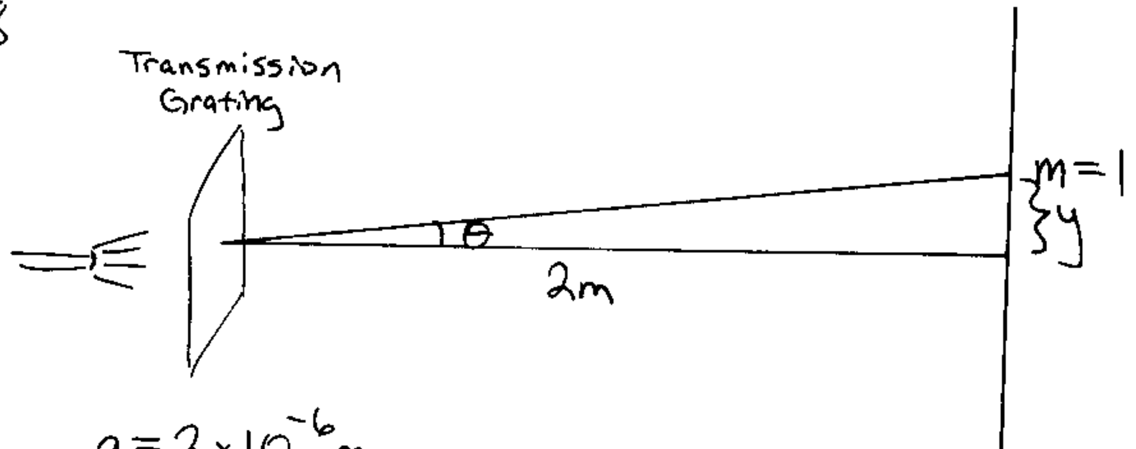


$$D\sin\theta = m\lambda$$

$$\lambda = \frac{D\sin\theta}{m} = \frac{(.20m)(\sin 36.87^\circ)}{1}$$

$$= .12m \text{ or } 12cm$$

78



$a = 3\times10^{-6}m$

$\lambda = 694.3\times10^{-9}m$

$$a\sin\theta = m\lambda$$

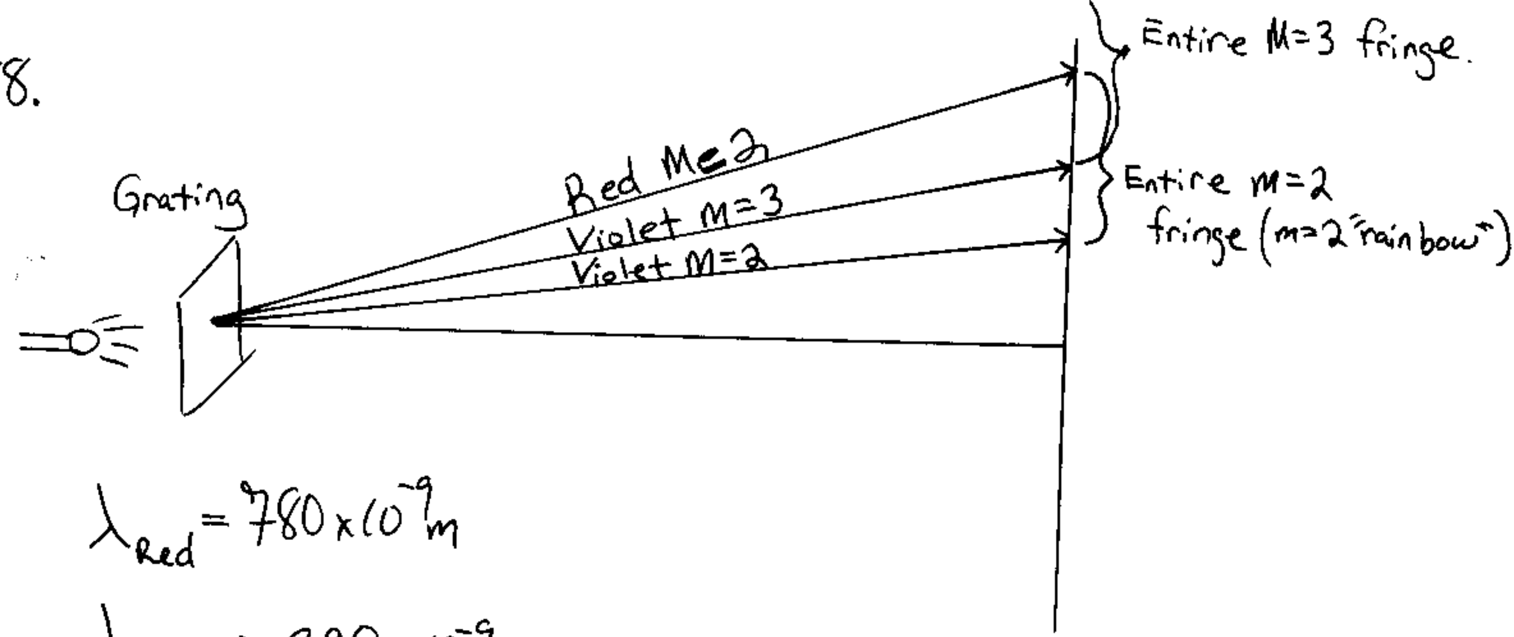
$$\theta = \arcsin\left(\frac{m\lambda}{a}\right) = \arcsin\frac{(1)(694.3\times10^{-9}m)}{3\times10^{-6}m}$$

$$= 13.3^\circ$$

$$\tan\theta = \frac{y}{2m} \Rightarrow y = 2\tan 13.3^\circ$$

$$= .47m$$

88.



$\lambda_{Red} = 780 \times 10^{-9} m$

$\lambda_{Violet} = 390 \times 10^{-9} m$

Grating has $5000 \frac{lines}{cm} = 5 \times 10^{5} \frac{lines}{m}$

$$a = \frac{1}{5 \times 10^{5} \frac{lines}{m}} = 2 \times 10^{-6} m$$

$$a \sin\theta = m\lambda \implies \theta = \arcsin\left(\frac{m\lambda}{a}\right)$$

for m=2 $\theta_{Red} = \arcsin\left[\frac{2(780 \times 10^{-9})}{2 \times 10^{-6}}\right] = 51.3^\circ$

$\theta_{Violet} = \arcsin\left[\frac{2(390 \times 10^{-9})}{2 \times 10^{-6}}\right] = 23^\circ$

for m=3 $\theta_{Red} = \arcsin\left[\frac{3(780 \times 10^{-9})}{2 \times 10^{-6}}\right]$ = No fringe b/c $\left(\frac{3(780 \times 10^{-9})}{2 \times 10^{-6}}\right) > 1$

$\theta_{Violet} = \arcsin\left[\frac{3(390 \times 10^{-9})}{2 \times 10^{-6}}\right] = 35.8^\circ$

Because the 3rd order fringe starts before the 2nd order fringe stops, they do overlap.

93. The hint says we need twice the radius of the Airy disk.

$$\rightarrow 2R_A = \frac{(2)(1.22)f\lambda}{D} \qquad f = 5m \quad \lambda = 650\times10^{-9}m \quad D = 1m$$

$$= \frac{(2)(1.22)(5)(650\times10^{-9})}{1}$$

$$= 7.93\times10^{-6}m$$

95. Diameter $= 2R_A$

$$R_A = \frac{1.22 f\lambda}{D} \qquad f = 17.1m \quad \lambda = 580\times10^{-9}m \quad D = .914m$$

$$2R_A = \frac{2(1.22)(17.1)(580\times10^{-9})}{.914}$$

$$= 2.65\times10^{-5}m$$

97.

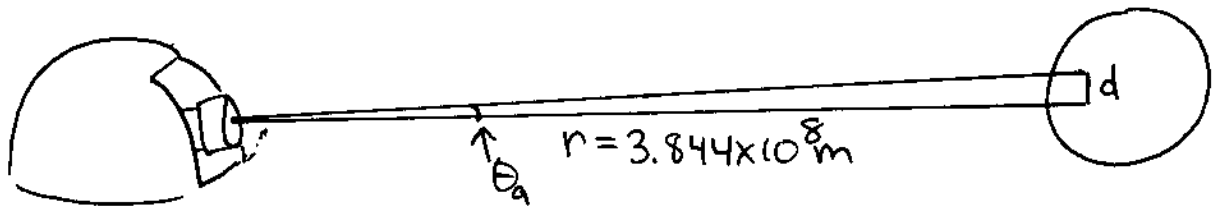
$$\theta_a = \frac{1.22\lambda}{D} \qquad \lambda = 550\times10^{-9}m \quad D = 5.08m$$

$$= \frac{1.22(550\times10^{-9})}{5.08} = \underline{1.32\times10^{-7}\,rad}$$

$$1.32\times10^{-7}rad\left(\frac{180^\circ}{\pi\,rad}\right) = \underline{7.57\times10^{-6\,\circ}}$$

$$7.57\times10^{-6\,\circ}\left(\frac{60\,min}{1^\circ}\right)\left(\frac{60\,sec}{1\,min}\right) = \underline{.027''}$$

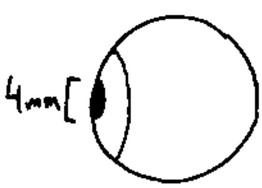
98.



Small angle approx. $r\theta = d$

$(3.844 \times 10^8 m)(1.32 \times 10^{-7}) = 50.7 m$

99.

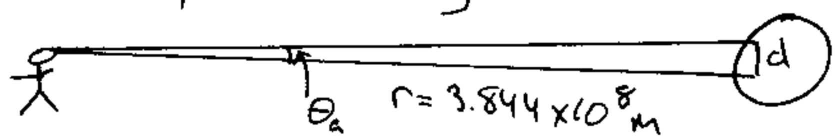


$\lambda = 550 \times 10^{-9} m$

$D = 4 \times 10^{-3} m$

$\theta_a = \frac{1.22\lambda}{D} = \frac{1.22(550 \times 10^{-9})}{4 \times 10^{-3}} = 1.68 \times 10^{-4} rad$

for human eye resolving at Earth-Moon distance



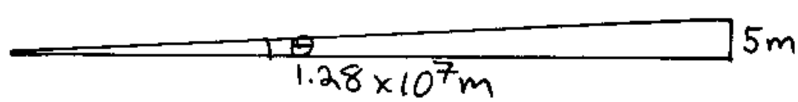
Small angle approx. $r\theta = d$

$(3.844 \times 10^8)(1.68 \times 10^{-4}) = 64{,}600 m$

or $64.6 km$

100. Hubble: $D = 2.4 m$, $\lambda = 500 \times 10^{-9} m$

$\theta_a = \frac{1.22(500 \times 10^{-9})}{2.4} = 2.54 \times 10^{-7} rad$



$r\theta = d \Rightarrow \theta = \frac{5}{1.28 \times 10^7} = 3.9 \times 10^{-7} rad > 2.54 \times 10^{-7} rad$

$\therefore$ Hubble can resolve the fireflies.