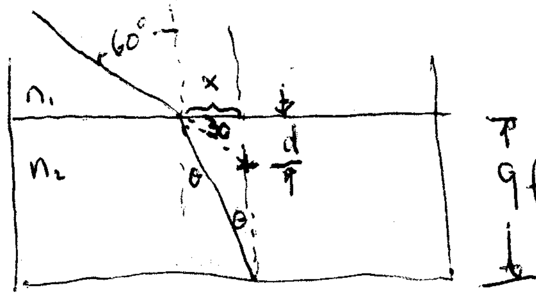
Problem 1)



a)

$$n_1 \sin 60° = n_2 \sin\theta$$

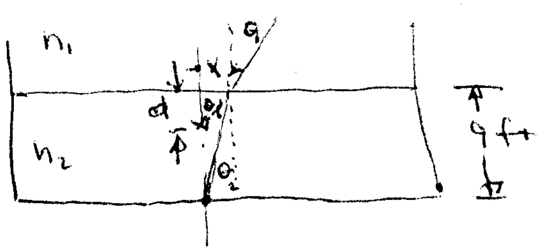
$$n_1 = 1 \qquad n_2 = 1.33$$

$$\sin\theta = 0.651 \qquad \theta = 40.6°$$

$$\tan\theta = \frac{x}{9} \qquad x = 9\tan 40.6 = 7.72\text{ ft.}$$

$$\boxed{d = x\tan 30 = 4.46\text{ ft.}}$$

b) At normal incidence.



For small angles: $\sin\theta \approx \tan\theta \approx \theta$

$$\therefore\ n_1\theta_1 = n_2\theta_2$$

$$\tan\theta_1 \approx \theta_1 = \frac{x}{d} \quad (1) \qquad d = \frac{x}{\theta_1}$$

$$\tan\theta_2 \approx \theta_2 = \frac{x}{9} \quad (2)$$

From (1) + (2) $\quad \frac{\theta_1}{\theta_2} = \left(\frac{x}{d}\right)\left(\frac{9}{x}\right)$ or $d = 9\frac{\theta_2}{\theta_1} = \frac{9}{n_2} = \frac{9}{1.33}$

$$\boxed{d = 6.76\text{ ft}}$$

Problem 2)

Lens equation for lens 1)

$$\frac{1}{d_o} + \frac{1}{d_i'} = \frac{1}{f_1} \quad (1)$$

Using $-d_i'$ for the ~~image~~ object distance of lens 2) the lens equation for lens 2) becomes:

$$-\frac{1}{d_i'} + \frac{1}{d_i} = \frac{1}{f_2} \quad (2)$$

Adding (1) and (2):

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f}$$

where $\boxed{f = \frac{f_1 f_2}{f_1 + f_2}}$

Problem 3)

The condition for a maximum for λ_1 is:

$$d \sin\theta = m\lambda_1 , \quad m = \text{order of maximum}$$

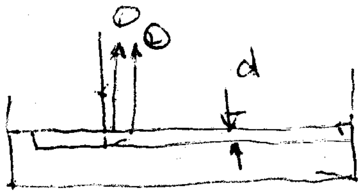
the condition for a minimum for λ_2 $(\lambda_1 > \lambda_2)$ is:

$$d \sin\theta = (m + 1/2)\lambda_2$$

$$\therefore \quad (m + 1/2)\lambda_2 = m\lambda_1$$

$$\text{or} \quad \boxed{m(\lambda_1 - \lambda_2) = \frac{\lambda_2}{2}}$$

Problem 4)



a) The condition for strongly reflected

$$2d = (m + \tfrac{1}{2})\lambda_1$$

and $$2d = (m + 3/2)\lambda_2$$

$$m\lambda_1 + \frac{\lambda_1}{2} = m\lambda_2 + \frac{3\lambda_2}{2}$$

$$m\,630 + \frac{630}{2} = m\,490 + \frac{3(490)}{2}$$

$$140m = \cancel{735} - 315 = 420$$

$$\therefore\ m = \frac{420}{140} = 3$$

and $$\boxed{d = \frac{7}{4}\lambda_1 = 1102.5 \text{ nm}}$$

b) If another wavelength is strongly reflected, we must have:

$$2d = (m - \tfrac{1}{2})\lambda \quad \text{or} \quad 2d = (m + 5/2)\lambda$$

$$\lambda = \frac{2(1102.5)}{2.5} = 882 \text{ nm} \qquad \lambda = \frac{2(1102.5)}{5.5} = 400.9$$

(outside wavelength range) o.k

$$\therefore\ \boxed{\lambda = 400.9 \text{ nm.}}$$

Problem 5:

a) $\vec{E} = E_0 \hat{j} \sin(kx - \omega t)$

$\bar{B} = \frac{E_0}{c} \hat{k} \sin(kx - \omega t)$

$\bar{S} = \frac{1}{\mu_0}(\bar{E} \times \bar{B}) = \frac{E_0^2}{\mu_0 c} \hat{i} \sin^2(kx - \omega t)$

$\langle \bar{S} \rangle = \frac{1}{2} \epsilon_0 c E_0^2 \qquad \left(\text{since} \quad c^2 = \frac{1}{\mu_0 \epsilon_0}\right)$

$\cancel{\frac{10^{-10}(2)}{8.85 \times 10^{-12}}} \qquad \langle \bar{S} \rangle = \frac{1}{2}(8.85 \times 10^{-12})(3 \times 10^8)(10^{-20})$

$= 13.3 \times 10^{-24}$ watts$/m^2$

b) If P is the power output of the source in watts,

then $\quad \langle S \rangle = \frac{P}{4\pi R^2} \quad$ or $\quad R = \sqrt{\frac{P}{4\pi \langle S \rangle}}$

$R = \sqrt{\frac{10^6}{4\pi(13.3 \times 10^{-24})}} = \sqrt{60 \times 10^{26}} = 7.75 \times 10^{13}\ m.$

$R = .0082$ light-years.