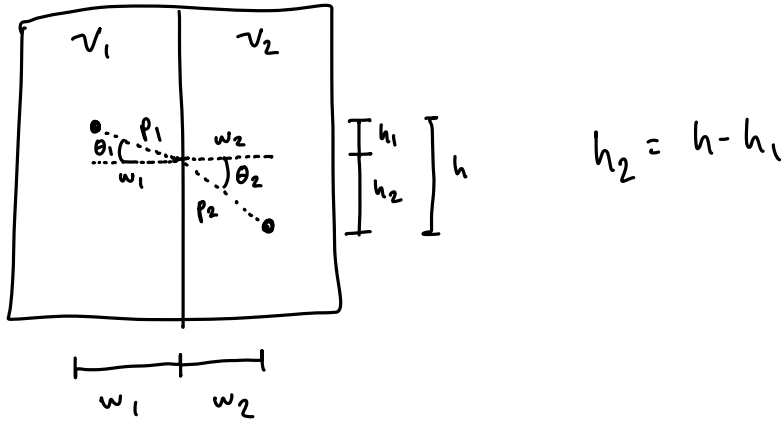


a.1



$$t = \frac{p_1}{v_1} + \frac{p_2}{v_2} = \frac{\sqrt{w_1^2 + h_1^2}}{v_1} + \frac{\sqrt{w_2^2 + (h-h_1)^2}}{v_2}$$

$$= \frac{1}{v_1} (w_1^2 + h_1^2)^{1/2} + \frac{1}{v_2} (w_2^2 + h^2 - 2hh_1 + h_1^2)^{1/2}$$

$$\frac{dt}{dh_1} = \frac{1}{2v_1} (w_1^2 + h_1^2)^{-1/2} \cdot 2h_1 + \frac{1}{2v_2} (w_2^2 + h^2 - 2hh_1 + h_1^2)^{-1/2} (-2h + 2h_1)$$

$$= \frac{h_1}{v_1 \sqrt{w_1^2 + h_1^2}} - \frac{h-h_1}{v_2 \sqrt{w_2^2 + h^2 - 2hh_1 + h_1^2}} = 0$$

$$\hookrightarrow \frac{1}{v_1} \cdot \frac{h_1}{\sqrt{w_1^2 + h_1^2}} = \frac{1}{v_2} \cdot \frac{h-h_1}{\sqrt{w_2^2 + h^2 - 2hh_1 + h_1^2}}$$

$\underbrace{\hspace{10em}}_{\sin \theta_1} \qquad \qquad \qquad \underbrace{\hspace{10em}}_{\sin \theta_2}$

$$\frac{1}{v_1} \sin \theta_1 = \frac{1}{v_2} \sin \theta_2$$

Since $v = \frac{c}{n}$, $\frac{n_1}{c} \sin \theta_1 = \frac{n_2}{c} \sin \theta_2$

$$\hookrightarrow n_1 \sin \theta_1 = n_2 \sin \theta_2$$

9.2 a) Fresnel's eqns: $E_1 = \frac{\sin(\theta_2 - \theta_0)}{\sin(\theta_2 + \theta_0)} E_0$

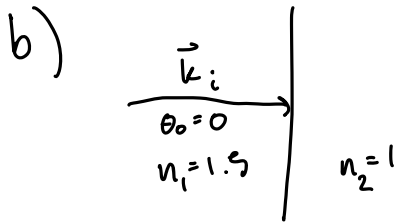
$$E_2 = \frac{2 \sin \theta_2 \cos \theta_0}{\sin(\theta_2 + \theta_0)} E_0$$

$$E_1 = \frac{\tan(\theta_0 - \theta_2)}{\tan(\theta_0 + \theta_2)} E_0$$

$$E_2 = \frac{2 \cos \theta_0 \sin \theta_2}{\sin(\theta_0 + \theta_2) \cos(\theta_0 - \theta_2)} E_0$$

$$\text{Reflectivity} = \frac{E_1}{E_0} = \frac{\sin(\theta_2 - \theta_0)}{\sin(\theta_2 + \theta_0)} = \frac{\tan(\theta_0 - \theta_2)}{\tan(\theta_0 + \theta_2)}$$

$$\text{Transmissivity} = \frac{E_2}{E_0} = \frac{2 \sin \theta_2 \cos \theta_0}{\sin(\theta_2 + \theta_0)} = \frac{2 \cos \theta_0 \sin \theta_2}{\sin(\theta_0 + \theta_2) \cos(\theta_0 - \theta_2)}$$



$$\frac{n_1}{n_2} = \frac{\sin \theta_2}{\sin \theta_0}$$

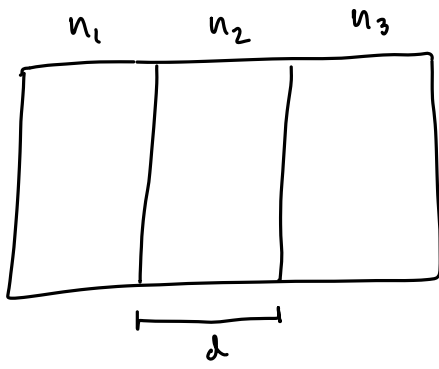
$$\frac{1.5}{1} = \frac{\sin \theta_2}{0} \Rightarrow \theta_2 = 0$$

Reflectivity = 0, no reflection

c) $\theta_B = \tan^{-1}\left(\frac{n_2}{n_1}\right) = \tan^{-1}\left(\frac{1}{1.5}\right) = .59 \text{ rad}$

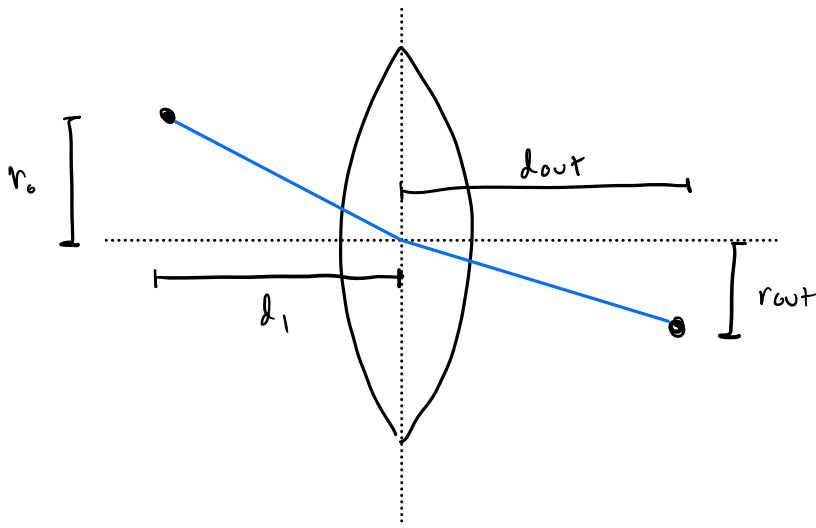
d) $\theta_C = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1}{1.5}\right) = .73 \text{ rad}$

q.3



?

q.4

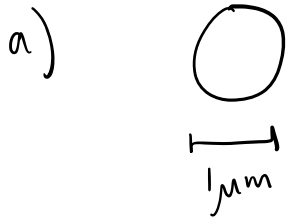


$$\begin{bmatrix} r_{out} \\ -r_{out}/d_{out} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -1/f & 1 \end{bmatrix} \begin{bmatrix} r_0 \\ -r_0/d_1 \end{bmatrix}$$

$$= \begin{bmatrix} r_0 \\ -r_0/f - r_0/d_1 \end{bmatrix}$$

$$= r_0 \begin{bmatrix} 1 \\ -\frac{1}{f} - \frac{1}{d_1} \end{bmatrix}$$

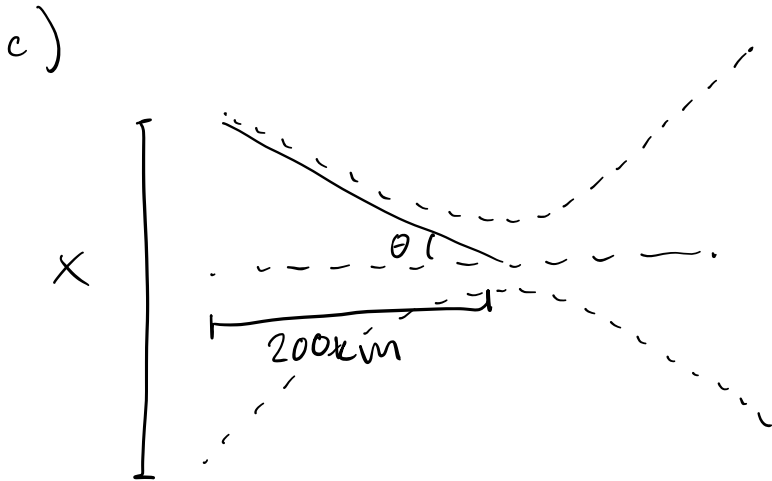
$$\boxed{9.5} \quad \lambda = 790 \text{ nm}$$



$$\theta = \frac{\lambda}{\pi n a} = \frac{790 \text{ nm}}{\pi \cdot 1.5 \cdot 1 \mu\text{m}} = .168$$

b)

$$.168 = \frac{\lambda}{\pi \cdot 1.5 \cdot 0.1 \mu\text{m}}$$
$$\hookrightarrow \lambda = 79 \text{ nm}$$



$$\tan \theta = \frac{x/2}{200 \mu\text{m}}$$

$$\theta = \frac{600 \text{ nm}}{\pi \cdot x}$$

$$\tan\left(\frac{6 \times 10^{-7}}{\pi \cdot x}\right) = \frac{x}{4 \times 10^5}$$

$$\hookrightarrow x = 0.276 \text{ m} = 27.6 \text{ cm}$$

9.6 ?