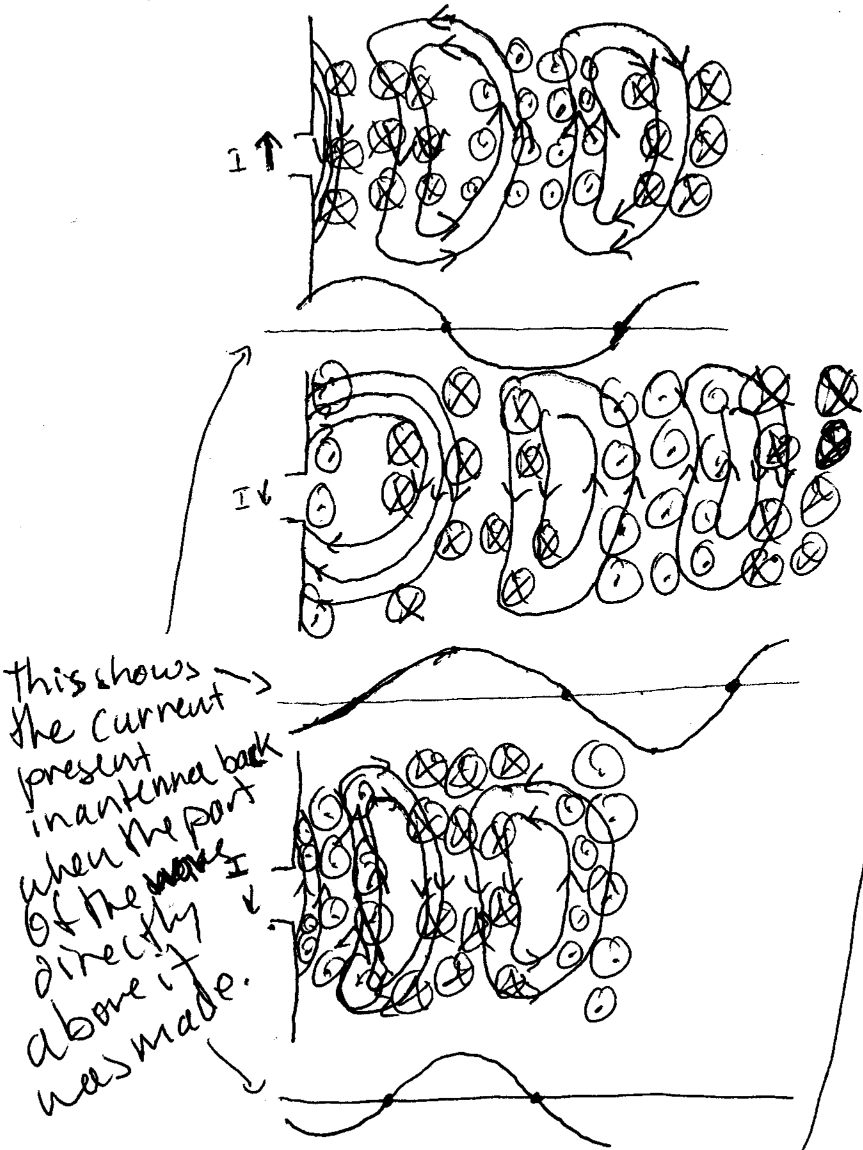
Prof. Lee, Spring 04 Midterm 1

Problem 1.

B field is always into ⊗ or out of ⊙ the page.

So the field lines I've drawn are E fields.

Note, although I can't draw it here, the B fields form giant loops which encircle the antenna, always.



Grading.

Points were awarded for showing the following:

$\boxed{1a}$
- E near antenna ends on wire.
- B goes around wire.
- Proper correlation of E direction with current.
- E x B should point out from antenna everywhere (as E x B is direction of propogation).

$\boxed{1b}$
- Far Away from antenna, E fields form closed loops (as do B's)
- E x B should give propogation direction everywhere
- Neighboring bubbles should have ↻ ↺ for E.
- E and B need to labelled correctly (and drawn correctly).

2

a) $\frac{1}{f} = \frac{1}{\infty} + \frac{1}{i_1} \Rightarrow i_1 = f$

$\frac{1}{-f} = \frac{1}{d_2} + \frac{1}{i_2}$; BUT $d_2 = L - i_1 = L - f$

$-\frac{1}{f} = \frac{1}{L-f} + \frac{1}{i_2}$

$i_2 = -\left(\frac{1}{L-f} + \frac{1}{f}\right)^{-1} = -\left[\frac{L}{(L-f)f}\right]^{-1} = \frac{f}{L}(f-L)$

$\Rightarrow i_2 > 0$ QED

b) $\frac{1}{-f} = \frac{1}{\infty} + \frac{1}{i_1} \Rightarrow i_1 = -f$

$\frac{1}{f} = \frac{1}{d_2} + \frac{1}{i_2}$; BUT $d_2 = L - i_1 = L + f$

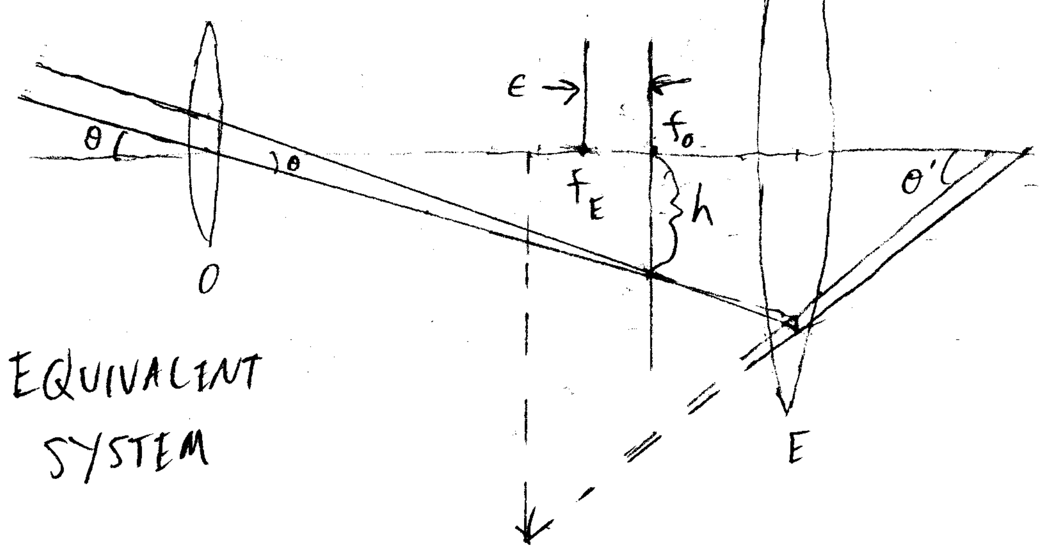
$\frac{1}{f} = \frac{1}{L+f} + \frac{1}{i_2} \Rightarrow i_2 = \left(\frac{1}{f} - \frac{1}{L+f}\right)^{-1} = \frac{f}{L}(f+L)$

$\Rightarrow i_2 > 0$ <u>NO</u>

c) $i_2 \to \infty$ – COMBINATION ACTS LIKE A FLAT SLAB IN THIN-LENS APPROX.

3

a)



$$\theta \simeq \tan\theta = -\frac{h}{f_o}, \quad \theta' \simeq \tan\theta' = \frac{h + (f_E - \epsilon)\tan\theta}{f_E - \epsilon} \simeq \frac{h}{f_E}$$

$$M = \frac{\theta'}{\theta} = -\frac{f_o}{f_E} \quad \text{QED}$$

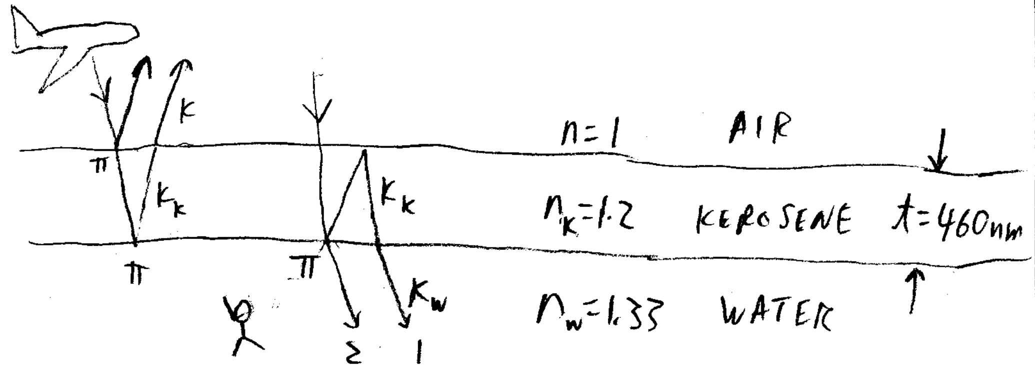
b) $h = f_o \tan\theta = f_o \dfrac{h_o}{d_o} = 16.8\,m \dfrac{1\,m}{2\cdot 10^3\,m} \rightarrow \boxed{h = 8.4\cdot 10^{-3}\,m}$

c) $f_E = \dfrac{f_o}{|M|} = \dfrac{R_o}{2|M|} = \dfrac{10\,m}{2\cdot 200} \rightarrow \boxed{f_E = 2.5\cdot 10^{-2}\,m}$

$\boxed{4}$

$k_k = n_k k;\ k_w = n_w k$

$k_x = \frac{2\pi}{\lambda_x}$



a) WANT CONSTRUCTIVE INTERFERENCE:

$$\Delta\phi = m\cdot 2\pi = \underbrace{k_k\cdot(2t)+\pi}_{\text{2nd REFLECTION}} - \underset{\text{1st REFLECTION}}{\pi} = \frac{2\pi}{\lambda} n_k(2t)$$

$$\Rightarrow \quad \lambda_m = \frac{2n_k t}{m}$$

$$\boxed{\lambda_2 = 552\ \text{nm (VACUUM)} \quad \text{(BRIGHT GREEN)}}$$ IN VISIBLE

b) MINIMA: $\Delta\phi = (2m+1)\pi = \underbrace{k_k\cdot(3t)+\pi}_{1} - \underbrace{k_k t}_{2} = \frac{2\pi}{\lambda}(2n_k t) + \pi$

$$\Rightarrow \lambda_m = \frac{2n_k t}{m} = \frac{2\cdot 1.2\cdot 460\,\text{nm}}{m} = \frac{1104\ \text{nm}}{m}$$

$$\boxed{\lambda_2 = 552\ \text{nm (BRIGHT GREEN)}}$$

MAXIMA:

$$\Delta\phi = m2\pi = k_k\cdot(3t)+\pi - k_k t = \frac{2\pi}{\lambda}(2n_k t)+\pi$$

$$\Rightarrow \lambda_m = \frac{2208\ \text{nm}}{2m-1} \Rightarrow \boxed{\begin{array}{ll} \lambda_2 = 736\ \text{nm} & \text{(DEEP RED)} \\ \lambda_3 = 441\ \text{nm} & \text{(BRIGHT BLUE)} \end{array} \quad \text{(VACUUM)}}$$