April 20, 2003

PHY 114 – Third exam solutions

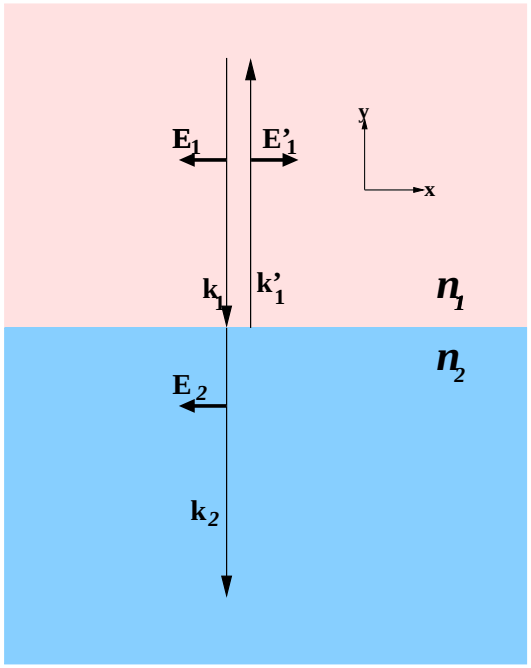
1. Write down Maxwell's equations, defining each of the terms.

   Coulomb-Gauss law: $\oint_{\text{area}} \mathbf{E}\cdot d\mathbf{A} = Q/\epsilon_0$.

   Gauss's law for magnetic fields: $\oint_{\text{area}} \mathbf{B}\cdot d\mathbf{A} = 0$.

   Biot-Savart-Ampere-Maxwell law: $\oint_{\text{line}} \mathbf{B}\cdot d\mathbf{s} = \mu_0 I + \mu_0\epsilon_0 \frac{d(\int \mathbf{E}\cdot d\mathbf{A})}{dt}$.

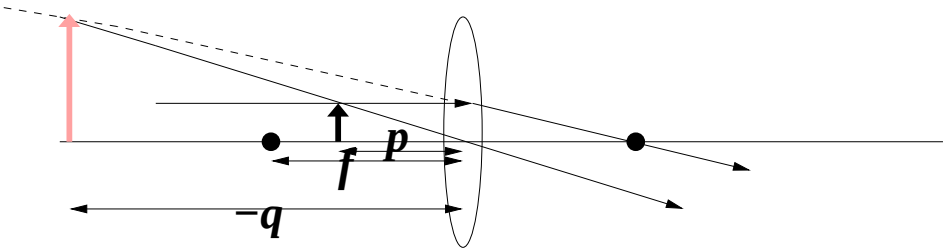
   Faraday's law: $\oint_{\text{line}} \mathbf{E}\cdot d\mathbf{s} = -\frac{d(\int \mathbf{B}\cdot d\mathbf{A})}{dt}$.

2. 

   (a) See figure above

   (b) $\mathbf{B}_{max_1} = \frac{E_{max_1}}{c}(-\hat{\mathbf{z}}) = 3.33 \times 10^{-8}$ T $(-\hat{\mathbf{z}})$ (into page)

   (c)
   i. $f_1 = 6 \times 10^{14}$ cycles/s
   ii. $f_1' = 6 \times 10^{14}$ cycles/s
   iii. $f_2 = 6 \times 10^{14}$ cycles/s
   iv. $\lambda_1 = c/f_1 = 5 \times 10^{-7}$ m $= 500$ nm.
   v. $\lambda_1' = \lambda_1 = 500$ nm.
   vi. $\lambda_2 = \lambda_1/n_2 = 333.33$ nm.
   vii. $E'_{max_1} = E_{max_1}\left(\frac{n_2-n_1}{n_2+n_1}\right) = 2$ N/C (in $\hat{\mathbf{x}}$ direction).

3. 

The ray diagram is shown above. The image is virtual

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}. \tag{1}$$

$$M=\frac{-q}{p} \quad \Rightarrow q=-Mp. \tag{2}$$

$$\frac{1}{p}\left(1-\frac{1}{M}\right)=\frac{1}{f}. \tag{3}$$

Solving this expression for p:

$$p=\frac{2}{3}f=6.67cm. \tag{4}$$

$$q=-3p=-20cm. \tag{5}$$

4.

$$2d\sin\theta=\lambda. \tag{6}$$

In this case, we know everything except for λ.

$$\lambda=2\cdot 0.463nm\sin(22^o)=0.34689nm. \tag{7}$$

From de Broglie's relation we can determine the momentum and then the kinetic energy of the electron.

$$p=\frac{h}{\lambda}. \tag{8}$$

$$K=\frac{p^2}{2m}=\left(\frac{h}{\lambda}\right)^2\frac{1}{2m}. \tag{9}$$

$$K=\left(\frac{6.626\times 10^{-34}}{0.34689\times 10^{-9}}\right)^2\frac{1}{2\cdot 9.11\times 10^{-31}}=2^{-18}J=12.5eV. \tag{10}$$

**********End of Exam**********