PHY101 AW 9 Solutions Fall 2017

(1) a) Start with $B = \frac{\mu_0 I}{2\pi r}$ and solve for r, or $r = \frac{\mu_0 I}{2\pi B}$

$$= \frac{\left(4\pi \times 10^{-7} \frac{Tm}{A}\right)(5\times 10^{3} A)}{2\pi (45 \times 10^{-6} T)} = \underline{22 m}$$

b) $B = \frac{\mu_0 I}{2\pi r} = \frac{\left(4\pi \times 10^{-7} \frac{Tm}{A}\right)(5\times 10^{3} A)}{2\pi (700 m)} = \underline{1.4 \times 10^{-6} T}$. Since this magnetic field is about 3% of the Earth's, the pigeons navigation system would hopefully not be affected by the power lines enough to not be able to fly home.

(2) Starting from the strength of the magnetic field in a solenoid, or $B = \mu_0 n I = \mu_0 \frac{NI}{L}$, we can solve for I, or $I = \frac{B}{\mu_0 n}$

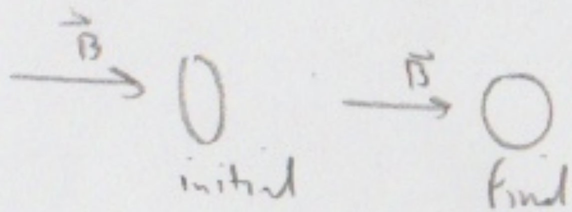
$$= \frac{(.24 T)}{\left(4\pi \times 10^{-7} \frac{Tm}{A}\right)(4850 m^{-1})} = \underline{39 A}.$$

(3) a) $\Delta V_{ind} = -\frac{\Delta \Phi_B}{\Delta t} = -\frac{(\Phi_{Bf} - \Phi_{Bi})}{\Delta t} = -\frac{(BA\cos(180^\circ) - BA\cos(0^\circ))}{\Delta t}$

$= -\frac{(-BA - BA)}{\Delta t} = \frac{2BA}{\Delta t} = \frac{2(.88\,T)\pi(.034m)^2}{.222s} = \underbrace{28.8\,mV}$

b) $R = \rho\frac{L}{A} = \frac{\Delta V_{ind}}{I} \Rightarrow I = \frac{\Delta V_{ind} A}{\rho L} = \frac{\Delta V_{ind}\pi\left(\frac{d}{2}\right)^2}{\rho\, 2\pi r} = \frac{\Delta V_{ind}\, d}{8\rho r}$

$= \frac{(.0288V)(.0009\,m)^2}{8(1.67\times10^{-8}\,\Omega m)(.034m)} = \underbrace{5.13\,A.}$

(4) 

$\rightarrow \Delta V_{ind} = -\frac{\Delta \Phi_B}{\Delta t} = \frac{-(\Phi_{Bf} - \Phi_{Bi})}{\Delta t} = \frac{BA}{\Delta t} =$

$\Phi_{Bi} = BA$ $\Phi_{Bf} = 0$

$\frac{B\pi r^2}{\Delta t} = \frac{(30\times10^{-6}T)\pi(.13m)^2}{2.7s} = .5\mu V$

$= \underbrace{5\times10^{-7}\,V}$

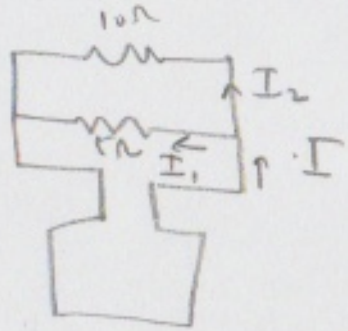
(5) a) $\Phi_{Bi} = BA$; $\Phi_{Bf} = -BA \rightarrow \Delta V_{ind} = -N\frac{\Delta\Phi_B}{\Delta t} = -\frac{N(-BA-BA)}{\Delta t}$

$$= 2\frac{NBA}{\Delta t} = \Delta V_{ind} = IR_{eq} = \frac{\Delta q}{\Delta t}R_{eq}$$

So, $\frac{2NBA}{\Delta t} = \frac{\Delta q}{\Delta t}R_{eq}$, or $\Delta q = \frac{2NBA}{R_{eq}} = 2NBA\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$

$$= 2(50)(1.4T)(.45m)^2\left(\frac{1}{10\Omega}+\frac{1}{5\Omega}\right) = \underline{8.5\,C}.$$

b) Use the junction rule $I = I_1 + I_2$ where I_1 and I_2 are



Since $I = \frac{\Delta q}{\Delta t}$, then $\frac{\Delta q}{\Delta t} = \frac{\Delta q_1}{\Delta t} + \frac{\Delta q_2}{\Delta t} \Rightarrow \Delta q = \Delta q_1 + \Delta q_2$.

Using the loop rule, $0 = IR_1 - I_2R_2$, around the two resistors, then

$0 = \frac{\Delta q_1}{\Delta t}R_1 - \frac{\Delta q_2}{\Delta t}R_2 \rightarrow \Delta q_1R_1 = \Delta q_2R_2$. Using $\Delta q = \Delta q_1 + \Delta q_2$ and $\Delta q_1R_1 = \Delta q_2R_2$, we can solve for Δq_2 by first solving for Δq_1 in $\Delta q = \Delta q_1 + \Delta q_2$ and then substituting it into $\Delta q_1 R_1 = \Delta q_2 R_2$, or

$$(\Delta q - \Delta q_2) R_1 = \Delta q_2 R_2$$

$$\Delta q R_1 - \Delta q_2 R_1 = \Delta q_2 R_2$$

$$\Delta q R_1 = \Delta q_2 R_2 + \Delta q_2 R_1$$

$$\Delta q R_1 = (R_1 + R_2) \Delta q_2$$

$$\frac{\Delta q R_1}{(R_1 + R_2)} = \Delta q_2$$

$$\frac{(8.5\,C)(10\,\Omega)}{10\,\Omega + 5\,\Omega} = 5.7\,C = \Delta q_2$$