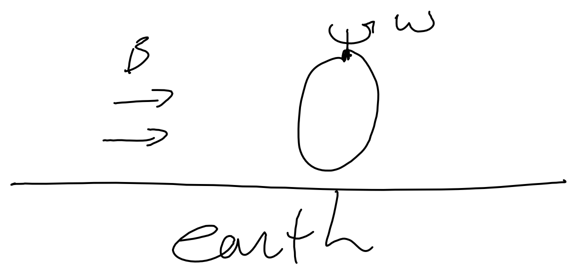
Tuesday, April 01, 2008
4:16 PM

Purcell 7.1



$$\mathcal{E} = -\frac{1}{c}\frac{d\Phi}{dt}$$

The flux is given by

$$\Phi = \int \vec{B}\cdot d\vec{a}$$

Since $\vec{B}$ is uniform and we want to maximize the Emf. We rotate the loop such that $\vec{\omega}$ is perpendicular to $\vec{B}$. So $\vec{B}\cdot d\vec{a}$ is given by,

$$\Phi = n B \int d\vec{a} \cos\theta = n B S \cos(\omega t)$$

$$\mathcal{E} = +\frac{1}{c} B S \omega \sin(\omega t)\cdot n$$

$$\mathcal{E}_{max} = \mathcal{E}(\sin(\omega t) = 1)$$

$$S = \pi r^2, \quad \omega = 2\pi f, \quad n = 4000$$

$$\mathcal{E}_{max} = \frac{B\pi r^2 2\pi f}{c} = \frac{0.5\,g\,\pi^2 (12cm)^2 \cdot 2 \cdot 30\,\frac{1}{s}\cdot 4000}{3\times10^{10}\,cm/s}$$

g = gauss

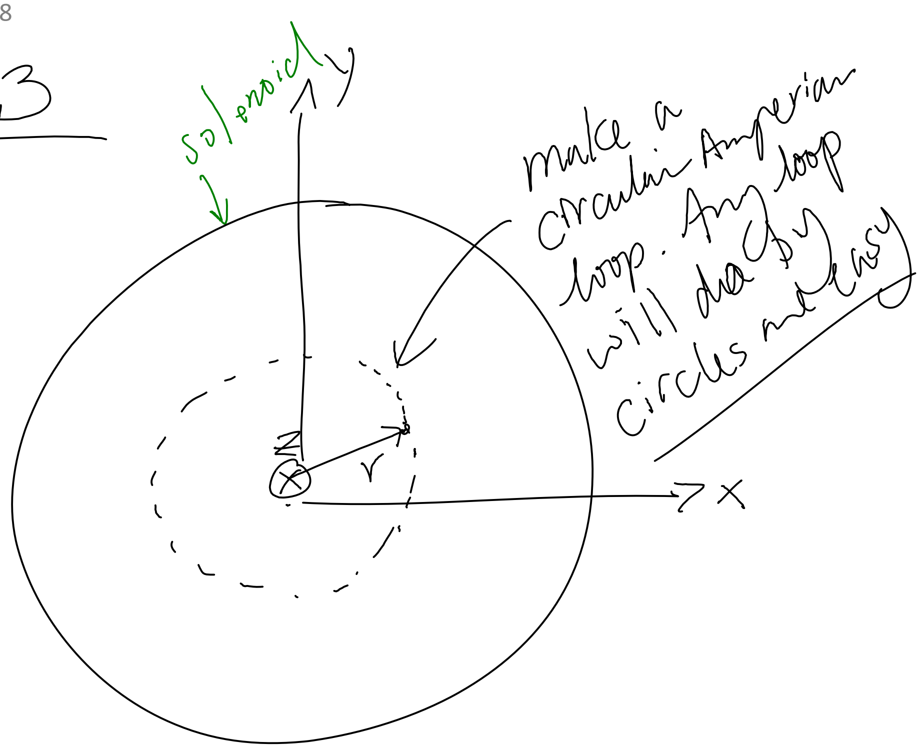
$$= 0.0057 \text{ statvolt}$$

$$\frac{g\,cm^2/s}{cm/s} = \text{gauss cm} = \frac{erg}{esu} = \text{statVolt}$$

7.3

Wednesday, April 09, 2008
6:26 PM

Purcell 7.3



$$\oint \vec{E} \cdot d\vec{s} = \frac{-1}{c}\frac{d}{dt}\int_S \vec{B}\cdot d\vec{a}$$

$\vec{s}$ is only in $\hat{\phi}$ direction

$$|E|\,2\pi r = \frac{-1}{c}\frac{d}{dt}\left(\pi r^2 B(t)\right)$$

$$\frac{d}{dt}B(t) = -2\pi 4 \times \left(2.5\times 10^6\right)\ \frac{\text{gauss}}{\text{sec}}$$

$$|E| = \frac{-1}{c}\frac{1}{2} r \frac{d}{dt}B(t)$$

$$|E| = \frac{3\,\text{cm}\left(2\pi\cdot 10^7\ g/s\right)}{3\times 10^{10}\ \text{cm}/s} = \pi\times 10^{-3}\ \text{gauss}$$

B & E have same units

7.4

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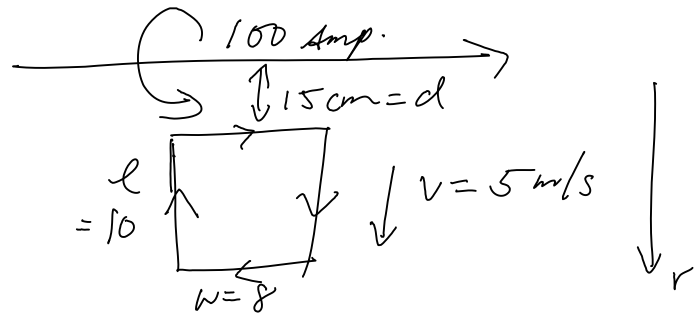
Purcell 7.4



$$\mathcal{E} = -\frac{1}{c}\frac{d\Phi}{dt} = -\frac{1}{c}\frac{d}{dt}\int \vec{B}\cdot d\vec{a}\ , \quad \vec{B} = \frac{2I}{cr}\hat{\phi},\ d\vec{a} = dr\,dw$$

$$= -\frac{1}{c^2} w \frac{2I}{1}\frac{d}{dt}\int_d^{l+d} \frac{1}{r}\,dr = -\frac{2Iw}{c^2}\frac{d}{dt}\ln\left(\frac{l+d}{d}\right)$$

only $d = d(t)$ so

$$= +\frac{2Iw}{c^2}\left(\frac{l}{ld + d^2}\right)\frac{d''d''}{dt} \quad (= v)$$

$$\boxed{= \frac{2Iwl}{c^2 d(l+d)} v = \mathcal{E}}$$

$$= \frac{2\cdot 3\times 10^{11}\ \text{esu/s}\cdot 8\,\text{cm}\cdot 10\,\text{cm}\cdot 500\,\text{cm/s}}{(3\times 10^{10}\,\text{cm/s})^2\cdot 15\,\text{cm}\,(25\,\text{cm})}$$

$$\boxed{= 7.1\times 10^{-8}\ \text{esu/cm.}}$$

$\frac{\text{esu}}{\text{cm}^2}\cdot\text{cm} = [E\cdot\text{length}]$
$= \text{statVolt}$

Loop also creates a $\vec{B}_L$ in the same direction as $\vec{B}_w$
discuss: what would be "safe".

7.7

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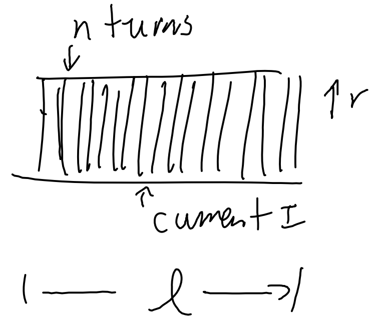
Purcell 7.7

~Uniform B-field inside solenoid.

$$B \approx \frac{4\pi I n}{c}$$



$$L = \mathcal{E} \Big/ \frac{dI}{dt}$$

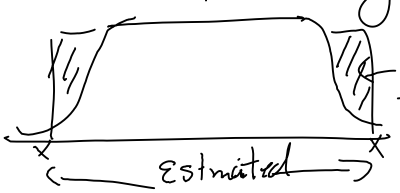
$$= -\frac{1}{c}\frac{d\Phi}{dt} \Big/ \frac{dI}{dt}$$

$$= -\frac{1}{c}\frac{d\Phi}{dI} = +\frac{1}{c}\frac{d}{dI}\int \vec{B}\cdot d\vec{a}$$

$$= +\frac{4\pi N^2}{l\,c^2}\pi r^2 \frac{d}{dI} I = \frac{4\pi^2 N^2 r^2}{l\,c^2}$$

$$= \frac{4\pi^2\, 1200^2\; 25\,cm^2}{200\,cm\,(3\times10^{10}\,cm/s^2)^2} = \boxed{7.90\times10^{-15}\ s^2/cm}$$

see chapter 6 fig 17



we get a smaller Φ so $L_{Actual} < L_{estimate}$

7.9 Purcell

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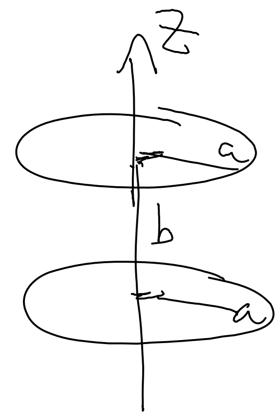

$$B_z = \frac{2\pi a^2 I}{c(a^2+b^2)^{3/2}}$$

for $b \gg a$

$$B_z \cong \frac{2\pi a^2 I}{c(b^3)}$$

$$\Phi = \frac{2\pi^2 a^4 I}{c\, b^3}$$

$$\mathcal{E} = -\frac{1}{c}\frac{d\Phi}{dt} = -\frac{1}{c}\frac{dI}{dt}\frac{d\Phi}{dI}$$

$$= -\frac{2\pi^2 a^4}{c^2\, b^3}\frac{dI}{dt}$$

$$\boxed{M = \frac{2\pi^2 a^4}{c^2 b^3}}$$

7.12

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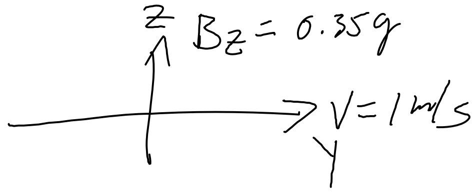


$\sigma = 0.04 \frac{1}{\Omega cm}$

find $J = \sigma E$

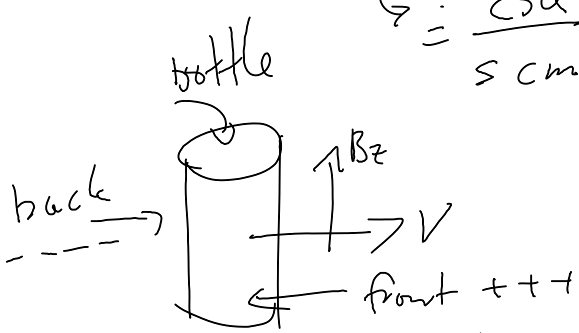
$\vec{E} = \frac{\vec{V}}{c} \times \vec{B} = \frac{vB}{c} \hat{x}$

$J = 0.35g \cdot 100\ cm/s \cdot 0.04 \frac{1}{\Omega cm} \cdot \frac{1}{3\times10^{10} cm/s}$

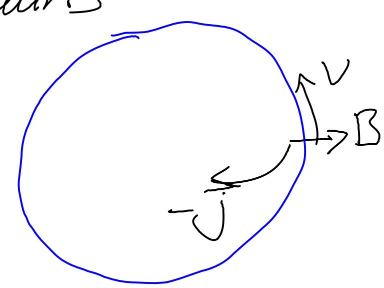
$= 4.7\times10^{-11} \frac{gauss}{cm \cdot \Omega} \cdot \frac{1\ \Omega}{1.113\times10^{-12}\ s/cm}$

$= 47 \frac{gauss}{s}$

$\overset{?}{=} \frac{esu}{s\ cm^2}$



we get an $\vec{E}$ that cancels the $\vec{E}_L$ from the Lorentz force.
No current. (also a current requires a complete circuit)
Like the earth as a circuit.



7.14

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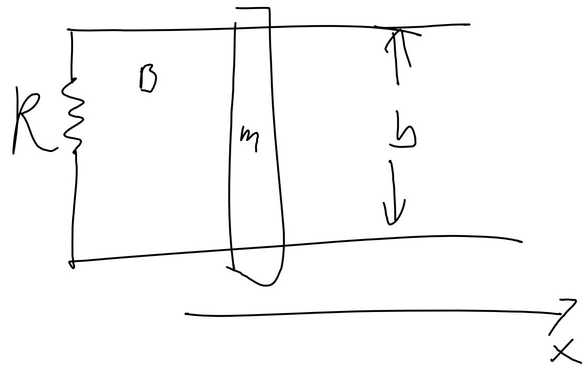

Purcell 7.14

a)

$$\Phi = b x B$$

$$\mathcal{E} = -\frac{1}{c}\frac{d}{dt}\Phi = -\frac{v}{c} b B = IR$$

The bar will have a force due to the moving charges.

$$\vec{f} = -|I| b B \hat{x}$$

Go back to Phys 21

$$F = ma = m\frac{dv}{dt} = |I| b B$$

$$= -\frac{v}{c}(bB)^2 \frac{1}{R}$$

$$v = v_0 \exp\left[-(bB)^2 t / mRC\right]$$

a) Bar stops at $t = +\infty$

b) $x = \int_0^\infty v\,dt = \frac{mRv_0}{Cb^2B^2}$

c) Energy is not conserved due to the resistor

7.17

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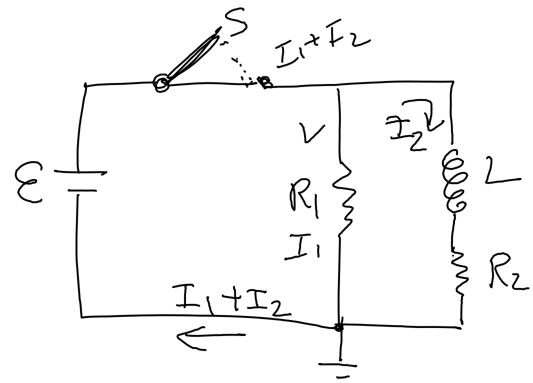
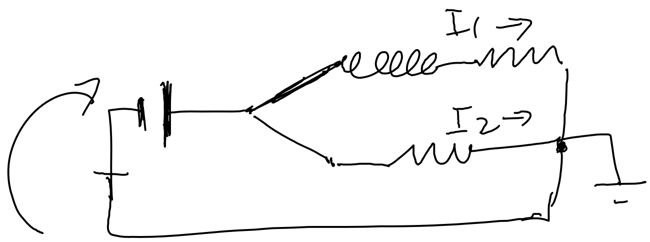


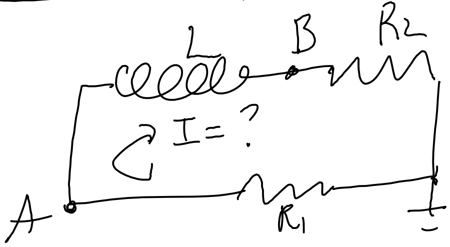
switch close

steady current flow through.

A better view is,



Switch opens:



L will try to keep $I = I_1$

$$IR_1 + L\dot{I} + IR_2 = 0$$

$$\dot{I} = -\left(\frac{R_1+R_2}{L}\right) I$$

$$I = -I_1 \exp\left(-\frac{(R_1+R_2)}{L} t\right)$$

drawn in opposite direction

7.17B

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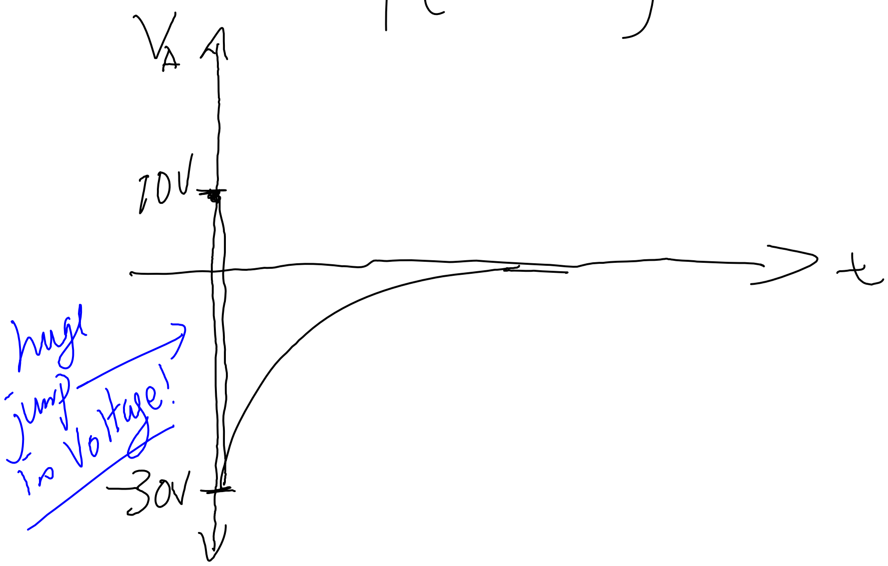
$$\frac{R_1+R_2}{L} = 200\,\frac{\Omega}{H}$$

$$V_A = I R_1,\quad I_1 = \frac{\mathcal{E}}{R_2} = \frac{10V}{50\Omega} = 0.2A$$

$$V_A = -0.2A\exp\left(-200\left(\tfrac{\Omega}{H}\right)t\right)\cdot 150\,\Omega$$

$$= -30(V)\exp\left(-200\left(\tfrac{\Omega}{H}\right)t\right)$$



$$V_B = I R_2$$

$$= 10(V)\exp\left(-200\left(\tfrac{\Omega}{A}\right)t\right)$$

7.21

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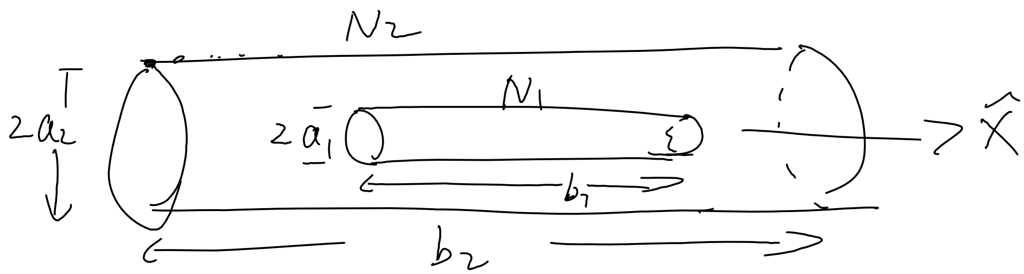
Purcell 7.21



$$\vec{B}_2 = \frac{N_2 I_2}{b_2}\hat{x}$$

$$\Phi_{12} = \frac{\pi a_1^2 N_1 N_2 I_2}{b_2}$$

$$\mathcal{E}_{12} = -\frac{d}{dt}\Phi_{12} = -\frac{\pi a_1^2 N_1 N_2}{b_2}\frac{dI_2}{dt}$$

$$M = \frac{\pi a_1^2 N_1 N_2}{b_2}$$