PHYS 350 E&M
Exam 6

April 19, 2017

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Assume Q on the inner shell

1. Two concentric metal spherical shells, of radius *a* and *b*, respectively, are separated by a weakly conducting material of conductivity σ as shown in Figure 1. What is the resistance between the shells?

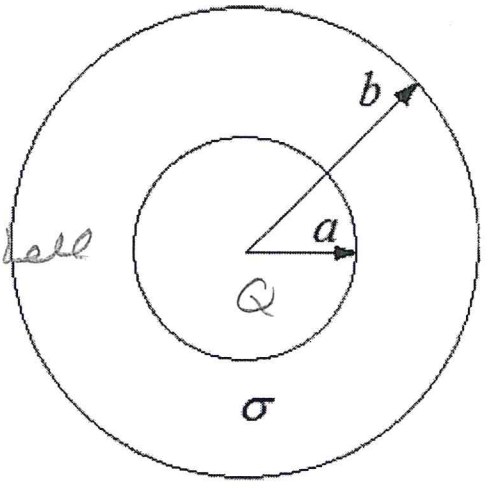

Figure 1

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

$$V = V_a - V_b = \frac{Q}{4\pi\epsilon_0}\left[\frac{1}{a} - \frac{1}{b}\right] = \frac{Q(b-a)}{4\pi\epsilon_0 ab}$$

$$I = \oint J \cdot da = \sigma \oint E \cdot da = \frac{\sigma Q}{\epsilon_0}$$

$$R = \frac{V}{I} = \frac{\frac{Q(b-a)}{4\pi\epsilon_0 ab}}{\frac{\sigma Q}{\epsilon_0}} = \frac{b-a}{4\pi\sigma ab}$$

$$\boxed{R = \frac{b-a}{4\pi\sigma ab}}$$

GRADES

100
98, 98
92
84

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2. Suppose the circuit in Figure 2 has been connected for a long time when suddenly, at time $t = 0$, switch S is thrown, bypassing the battery.

   What is the current at any subsequent time t? $I(t) = \frac{\mathcal{E}_0}{R} e^{-\frac{R}{L}t}$

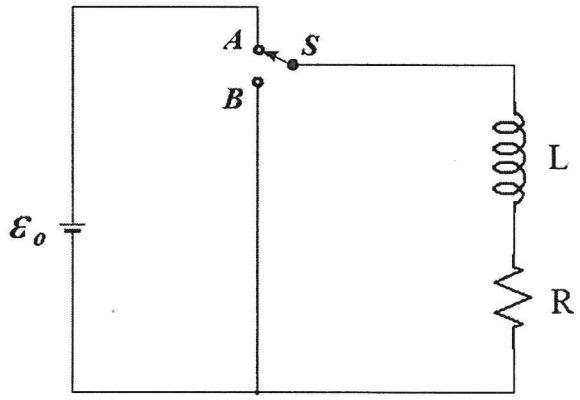

Figure 2

$$0 = V_L + V_R$$

$$-L\frac{dI}{dt} + IR$$

$$\frac{L}{R}\frac{dI}{dt} + I = 0$$

$$I = Ae^{st}$$

$$\frac{dI}{dt} = sI$$

$$\frac{L}{R}sI + I = 0$$

$$s = -\frac{R}{L}$$

$$I = Ae^{-t/\tau} \qquad \tau = \frac{L}{R}$$

@ $t = 0$ $\quad I = \frac{\mathcal{E}_0}{R}$

$$\boxed{I = \frac{\mathcal{E}_0}{R} e^{-t/\tau} \qquad \tau = \frac{L}{R}}$$

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3. The conducting bar in Figure 3 slides on conduction rails. The bar is driven sinusoidally so that $x = 0.1\sin 20t$ m. If **B** = 0.5 Tesla out of the paper, and L = 0.2 m, find V.

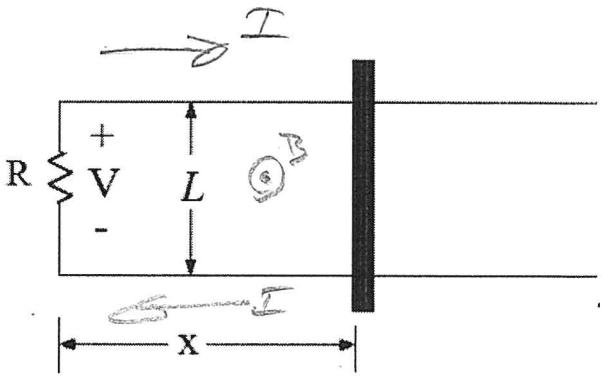

Figure 3

$\Phi = BA = BLx$

$V = \frac{d\Phi}{dt}$ If x increases Φ increases

By Lenz's Law a current will flow to try to cancel the increase by producing a B field into the paper, in the direction shown.

i.e. A positive increase in flux produces a negative voltage

$$V = -\frac{d\Phi}{dt} = -BL\frac{dx}{dt} = -BL\frac{d}{dt}(0.1\sin 20t)$$

$$= -BL\,0.1 \times 20\cos 20t$$

$$V = -\frac{1}{2} \times 0.2 \times 2\cos 20t$$

$$\boxed{V = -0.2\cos 20t}$$