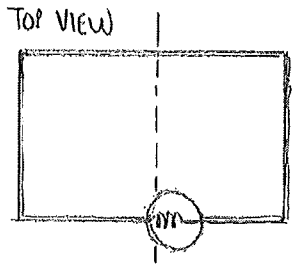
Physics 161 Fall 2010 Exam 7 **Last Name First Name**
Closed book closed notes calculators OK.

$\mu_0 = 4\pi \times 10^{-7}$ Wb/A · m $\quad \oint \vec{B} \cdot d\vec{s} = \mu_0 I$

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = \oint \vec{E} \cdot d\vec{l} \qquad V_L = -L\frac{di}{dt} \qquad U_L = \tfrac{1}{2}Li^2 \qquad T = \frac{2\pi}{\omega}$$

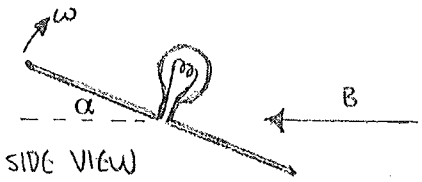
$$\Phi_B = \int \vec{B} \cdot d\vec{A} \qquad V_C = \frac{Q}{C} \qquad U_C = \tfrac{1}{2}\frac{Q^2}{C} \qquad \omega = \frac{1}{\sqrt{LC}}$$

1&2. A square loop has area 2 m^2 and rotates at an angular frequency of ω=1 rad/s in a uniform magnetic field of 110 T. A light bulb, with resistance 3 Ω, is connected across a small gap in the loop. When the angle α shown is 18°, what is the magnetic flux through the loop, in Webers?



3&4. At the instant shown, what is the voltage drop across the bulb (in Volts)? Assume the wires have no resistance.

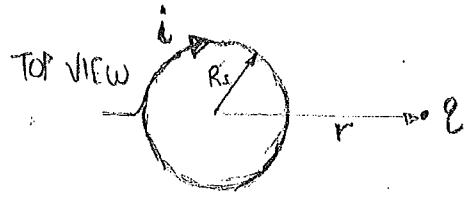
5. What is the direction of current flow through the bulb at this instant?
A] There is no current flow
B] Clockwise, viewed from above
C] Counterclockwise, viewed from above
D] It depends on the sign of the charge carriers

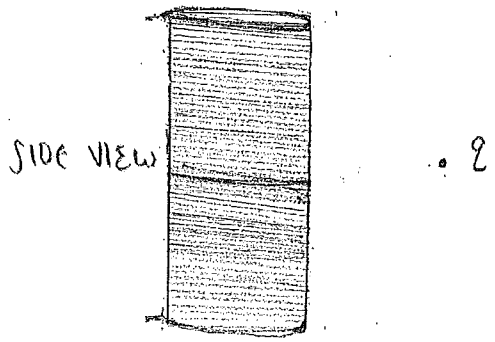


6&7. A long solenoid has a **decreasing** current through it, i=20-2t, t in seconds, i in amperes. This formula for the current is valid for all times of interest. The current flows clockwise in the solenoid, as seen from above.

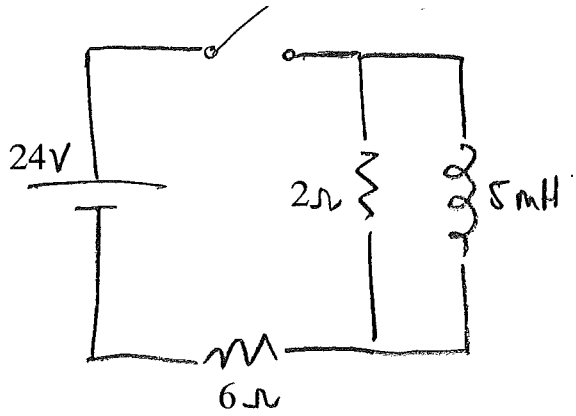
The solenoid has 2000 turns per meter and has a radius R_s = 0.1 m. At time t=0, what is the magnitude of the electric field at point q, a distance r=0.25 m from the solenoid axis, in the middle of the solenoid? Give your answer in microvolts per meter.

8. What is the direction of the electric field at point q, **in the "side view"?**
A] there is no E field
B] left (toward the solenoid)
C] right (away from the solenoid)
D] up
E] down
F] out of the page
G] into the page
H] some other direction





9] In the circuit shown, immediately after closing the switch, what is the current through the battery in amps?
10] What is the current through the battery a long time after closing the switch?

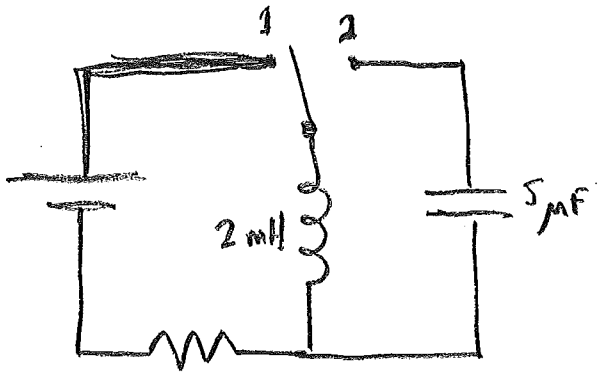


11] In the circuit below, the battery is 20 V and the resistor is 4 Ohms. The switch is set to position 1 until a steady current is reached. What is that current, in Amperes?

12] When there is a steady current, what is the voltage across the *capacitor?* (in V)

13&14] The switch is rapidly thrown to position 2. What is the maximum charge on the capacitor at any time after the switch is thrown (in microCoulombs)?

15&16] How long after the switch is thrown is the maximum charge on the capacitor observed (in microseconds)?



1&2] $\Phi = \int \vec{B} \cdot d\vec{A} = BA\cos\theta = 110 \cdot 2 \cdot \cos(90-18^\circ) = 68$ Wb.

3&4] $\frac{d\Phi}{dt} = \omega BA\sin\theta = 1 \cdot 2 \cdot 110 \cdot \sin(90-18^\circ) = 209\text{V} = \mathcal{E}$

5] c. CCW.

6&7] $\oint \vec{E} \cdot d\vec{l} = \frac{d\Phi}{dt}$ $\frac{d\Phi}{dt} = \frac{dB}{dt} \cdot A_{sol}$

$B = \mu_0 n I$ $\frac{dB}{dt} = \mu_0 n \frac{dI}{dt} = -5\times10^{-3}\ \frac{T}{s}$

$\frac{d\Phi}{dt} = -5\times10^{-3} \cdot \pi \cdot (0.1)^2 = 1.57\times10^{-4} = E \cdot 2\pi r$

$E = 1\times10^{-4}$ V/m $= 100\ \mu$V/m

8] Flux is down & decreasing,
to oppose change, field should be down in the top view
& out of page in side view. [F]

9] $\sim\!\!\!\!\sim$ = open. $\frac{24\text{V}}{8\Omega} = 3\text{A}$.

10] $\sim\!\!\!\!\sim$ = short. $\frac{24\text{V}}{6\Omega} = 4\text{A}$.

11] $\sim\!\!\!\!\sim$ = short $\frac{20\text{V}}{4\Omega} = 5\text{A}$.

12] 0V.

13&14] $\frac{1}{2}Li^2 = \frac{1}{2}\frac{Q^2}{C}$ $Q_{max} = \sqrt{LC}\, i_{max} = 5\times10^{-4}\text{C} = 500\ \mu\text{C}$.

15&16] $\frac{1}{4}T = \frac{\pi}{2\omega} = \frac{\pi}{2}\sqrt{LC} = 1.57\times10^{-4}\text{s} = 157\ \mu\text{s}$ Rounds to 200 μs.