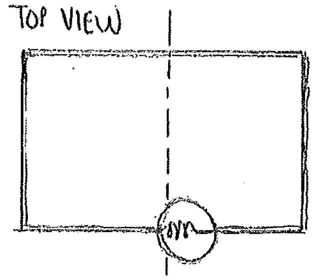
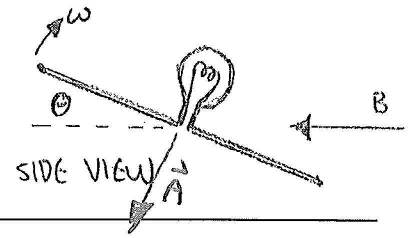
Physics 161 Fall 2010 Exam 7
Numbers may be changed on the real exam. Closed book closed notes calculators OK.



1&2. A square loop has area 2 m^2 and rotates at an angular frequency of 20 rad/s in a uniform magnetic field of 11 T. A light bulb, with resistance 3 Ω , is connected across a small gap in the loop. When the angle θ shown is 20°, what is the magnetic flux through the loop, in Webers? see attached.

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

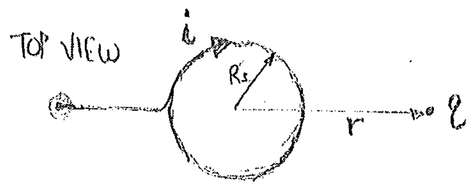


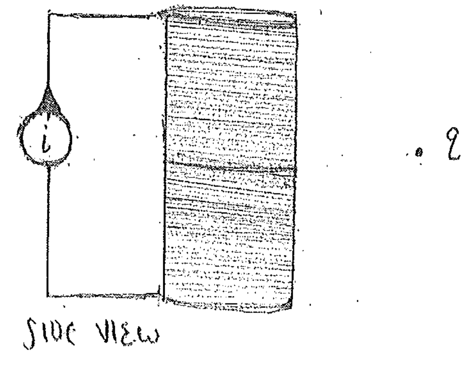
5. What is the direction of current flow through the bulb at this instant?
A] There is no current flow
B] Clockwise, viewed from above
C] Counterclockwise, viewed from above
D] It depends on the sign of the charge carriers

6&7. A long solenoid has an increasing current through it, i=4t, t in seconds, i in amperes. This formula for the current is valid for all times of interest. see attached.

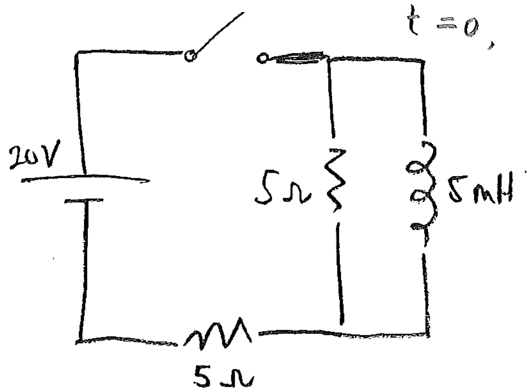
The solenoid has 6000 turns per meter and has a radius R_s = 0.1 m. At time t=0, what is the magnitude of the electric field at point q, a distance r=0.3 m from the solenoid axis, in the middle of the solenoid?

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?



$t=0$, Inductor = open circuit.

$I = \frac{20V}{10\Omega} = 2A.$

$t=\infty$, Inductor = short

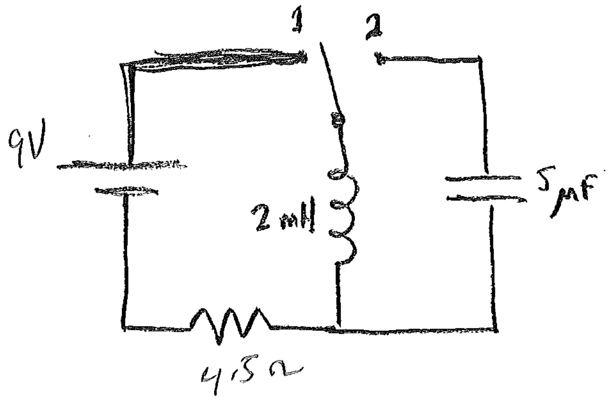
$I = \frac{20V}{5\Omega} = 4A.$

11] In the circuit below, the battery is 9 V and the resistor is 4.5 Ohms. The switch is set to position 1 until a steady current is reached. What is that current, in Amperes? $I = \frac{9V}{4.5\Omega} = 2A$

12] When there is a steady current, what is the voltage across the *capacitor?* (in V) 0. It's not connected!

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)?



13&14] $U_L = U_C$

$\frac{1}{2}LI^2 = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$

$Q = \sqrt{LC}\,I = 10^{-4}\,I$

$Q = 2\times10^{-4}$ Coulombs

$= 200\ \mu C.$

15&16] $\frac{1}{\omega} = \sqrt{LC} = 10^{-4}$ $\omega = 10^{4}$

$T = \frac{2\pi}{\omega} = 6.3\times10^{-4}\ s.$

Max Charge in $\frac{T}{4}$. $= 1.57\times10^{-4}\ s$

$= 157\ \mu s.$

1&2. Flux $= \int \vec{B}\cdot d\vec{A} = BA\cos\theta$ but θ here is NOT θ in the sketch! $\theta = 90° - \theta_{sk}$. so $\Phi_m = B\cdot A\cdot\cos(90° - \theta_{sk}) = BA\cos 70°$

$= 11\cdot 2\cdot\cos 70° = 7.52$ Wb.

3&4. $\frac{d\Phi}{dt} = B\cdot A\cdot\frac{d}{dt}[\cos(90° - (\theta_{sk} + \omega t))]$

$= \omega\cdot B A \sin(90° - (\theta_{sk} + \omega t))\Big|_{t=0} = \omega B A \sin 70° = 413$ V.

6&7 $\oint \vec{E}\cdot d\vec{l} = -\frac{d\Phi_m}{dt}$ $\Phi_m = BA_s$. $\oint \vec{B}\cdot d\vec{l} = \mu_0 N I. = B\cdot l$

$B = \mu_0 \frac{N}{l}\cdot I = \mu_0\cdot 6000\cdot 4t = 0.03t$

$A_s = \pi r^2 = 0.0314\ m^2$.

$\frac{d\Phi_m}{dt} = \frac{dB}{dt}A_s = 0.03\cdot 0.0314 = 9.4\times10^{-4}$

$= 2\pi r\cdot E$ $E = 5\times10^{-4}$ V/m.

8. Flux is down & increasing (top view)
so induced $\vec{E}$ is CCW. (top view)