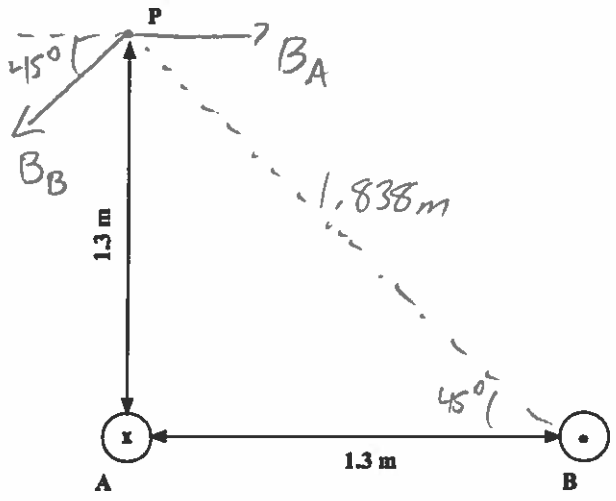
Physics 10164 - Summer 2017 - Exam #2

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (35 pts) Two long straight wires pass through the x-axis as shown and carry currents of I_A = 2.4 A, directed into the page and I_B = 2.8 A out of the page.

a) Find the magnitude and direction of the resulting magnetic field at point P along the y-axis.

b) Find the magnitude and direction of the magnetic force on a +7.2 μC charge moving through point P in a direction into the page. $v = 3.5 \times 10^5$ m/s



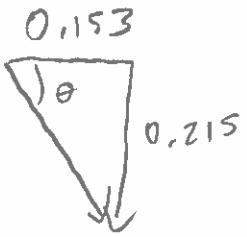
$$|B_A| = \frac{\mu_0 I_A}{2\pi r_A} = 0.369\ \mu T$$

$$|B_B| = \frac{\mu_0 I_B}{2\pi r_B} = 0.305\ \mu T$$

$B_{Ax} = 0.369 \quad B_{Ay} = 0$

$B_{Bx} = -0.215 \quad B_{By} = -0.215$

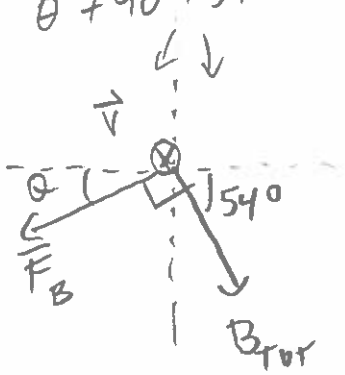
$B_{TOTx} = 0.153 \quad B_{TOTy} = -0.215$



$$|B_{TOT}| = \sqrt{.153^2 + .215^2} = \boxed{0.26\ \mu T}$$

$$\theta = \tan^{-1}\left(\frac{.215}{.153}\right) = \boxed{54^\circ \text{ below } +x}$$

$\theta + 90 + 54 = 180^\circ$



$$|F_B| = |qvB| \sin\theta$$

$$= |7.2\times10^{-6}|(3.5\times10^5)(0.26\times10^{-6})(1)$$

$$= \boxed{6.6 \times 10^{-7}\ N}$$

$$\theta = \boxed{36^\circ \text{ below } -x}$$

2. (35 pts) In the figure below, we are looking along the axis of a 3500-turn, 78-cm long solenoid with radius 3.8 cm. There is a 1.3 Amp current in the solenoid flowing in a clockwise direction. Inside the solenoid is a single-turn square loop, 3.4 cm on a side oriented with its plane perpendicular to the axis of the solenoid.

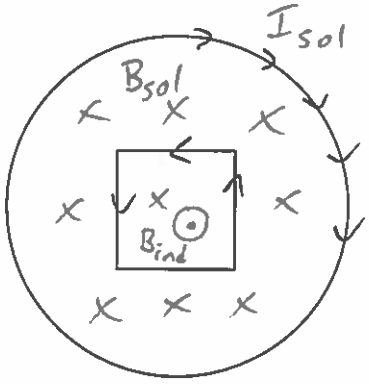
Assume that the current in the solenoid increases to 3.1 Amps in a time interval of 0.065 sec. Res = 3.5 Ω

a) What is the initial direction of the flux in the square loop?

b) Is the flux in the square loop increasing or decreasing?

c) In what direction is the induced magnetic field in the loop?

d) What is the magnitude and direction of the induced current in the square loop during this time interval?



a) $\Phi_B = \otimes$ since $B_{sol} = \otimes$ due to RHR #3

b) $\Delta\Phi_B$ = increasing since I_{sol} increasing

c) $B_{ind} = \odot$ to oppose increasing $\otimes$

d) $B_i = \frac{\mu_0 N I_i}{L} = \frac{(4\pi \times 10^{-7})(3500)(1.3)}{0.78} = .00733\ T$

$B_f = \frac{(4\pi \times 10^{-7})(3500)(3.1)}{0.78} = .01748\ T$

$\mathcal{E}_{ind} = \frac{N_{sq}\,\Delta B A \cos\theta}{\Delta t} = \frac{(1)(.01015)(.034)^2(1)}{.065} = 1.8 \times 10^{-4}\ V$

$I_{ind} = \frac{1.8 \times 10^{-4}}{3.5} = 5.2 \times 10^{-5}\ A$

Dir = ccw to be consistent with B_{ind} (RHR #3)

#3. (30 pts) An AC source operates at a frequency of 60.0 Hz with an rms voltage of 120 Volts. It is connected in series with a 44 Ohm resistor and an unknown inductor. The rms current in the circuit is measured to be 0.89 Amps.

a) What is the value of the inductance?

b) What is the maximum value of the voltage drop across the resistor?

c) What is the maximum value of the voltage drop across the inductor?

d) When the current is equal to zero in the circuit, what is the voltage drop across (i) the resistor, (ii) the inductor, and (iii) the power source? Briefly explain and/or mathematically justify each of your three answers.

a) $X_L = 2\pi f L = ?$

$I_{rms} = \frac{\mathcal{E}_{rms}}{Z}$

$0.89 = \frac{120}{Z}$

$Z = 134.83$

$134.83^2 = R^2 + X_L^2$

$16244 = X_L^2$

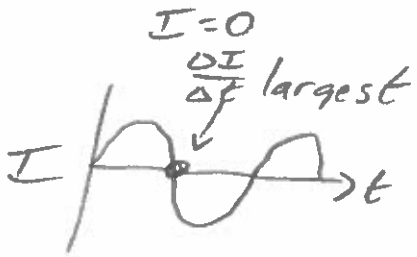
$X_L = 127.45 = 2\pi(60)L$

$\boxed{L = 0.34\ H}$

b) $I_{max} = 1.26\ A$

$\Delta V_{R,MAX} = I_{max} R = \boxed{55\ \Omega}$

c) $\Delta V_{L,MAX} = I_{max} X_L = \boxed{160\ \Omega}$



d) If $I = 0$, $\boxed{\Delta V_R = 0}$ since $\Delta V_R = IR$

When $I = 0$, $\frac{\Delta I}{\Delta t}$ is largest, so $\boxed{\Delta V_L = 160\ V}$

$\boxed{\Delta V_{\mathcal{E}} = 160\ V}$ due to loop rule