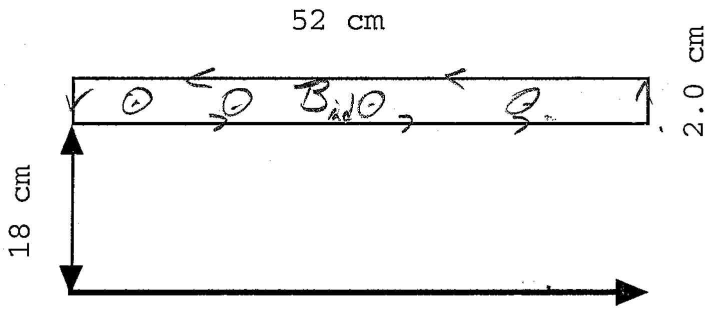
Physics 10164 - Exam 3B

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. (30 pts) In the wire below, there is an initial current of 3.0 Amps in the direction shown, and that current decreases to zero in 0.12 seconds. What is the magnitude and direction of the current in the rectangular loop, assuming the magnetic field is uniform thoughout the loop (equal to whatever its value is in the center of the loop)? The resistance in the loop is 0.054 Ohms.



$\Delta\Phi = \odot$, decreasing

$\rightarrow B_{ind} = \odot$

$I_{ind} =$ CCW

$$B \text{ in loop} = \frac{\mu_0 I}{2\pi r} = \frac{(2\times10^{-7})(3.0)}{0.19\text{ m}} = 3.16\times10^{-6}\text{ T}$$

$$\mathcal{E} = N\frac{\Delta\Phi}{\Delta t} = (1)\frac{(3.16\times10^{-6})(.02\times.52)(1)}{.12} = 2.7\times10^{-7}\text{ V}$$

$$I = \frac{2.7\times10^{-7}}{.054} = 5.1\times10^{-6}\text{ A} \quad \text{CCW}$$

2. (20 pts) A DC circuit has a 5.0 Ohm resistor and a 0.027 H inductor and an emf of 24 Volts.

a) At what time is the voltage drop across the inductor equal to the voltage drop across the resistor?

b) At what time is the voltage drop across the inductor equal to 1.0 Volts?

$$\tau_L = \frac{L}{R} = \frac{.027}{5} = .0054\ s$$

a) Want $\Delta V_L = 12 = 24 e^{-t/\tau}$

$$0.5 = e^{-t/\tau}$$

$$-0.693 = -\frac{t}{\tau}$$

$$t = (0.693)(.0054) = \boxed{.0037\ s}$$

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b) $\Delta V_L = 1 = 24 e^{-t/\tau}$

$$\ln\left(\frac{1}{24}\right) = -\frac{t}{\tau}$$

$$-3.18 = -\frac{t}{.0054}$$

$$\boxed{t = .017\ s}$$

3. (30 pts) An RLC circuit has a voltage source with an rms voltage of 18 Volts, a 0.250 H inductor, and a 45 μF capacitor. $R = 6.0\,\Omega$

a) When this circuit is operating at the resonant frequency, what is the rms current?

b) The capacitance is changed by alterating the plate separation, and so it is now 31μF but operating at the same frequency as in part (A). What is the rms current?

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = 47.4\ Hz$$

$$I_{rms} = \frac{\mathcal{E}_{rms}}{Z} = \frac{18}{6.0} = 3.0\ A$$

$$X_L = 2\pi(47.4)(0.250) = 74.46\ \Omega$$

$$X_C = \frac{1}{2\pi(47.4)(31 \times 10^{-6})} = 108.3\ \Omega$$

$$Z = \sqrt{6.0^2 + (-33.8)^2} = 34.4\ \Omega$$

$$I_{rms} = \frac{18}{34.4} = \boxed{0.52\ A}$$

4. (20 pts) A transformer at a power plant steps up the generator voltage from 8,800 Volts to 320,000 Volts, and it delivers 14 Megawatts over power lines with a resistance of 352 Ohms.

Calculate the percentage of power that is lost relative to the amount of power that is provided by the power plant.

$$14 \times 10^6 \, W = (\Delta V_{wire})(I_{wire})$$

$$I_{wire} = \frac{14 \times 10^6 \, W}{320{,}000 \, V} = 43.75 \, A$$

$$P_{loss} = I_{wire}^2 R_{wire}$$

$$= 674{,}000 \, W$$

$$\% \, loss = \frac{P_{loss}}{P_{tot}} * 100 = \frac{674{,}000}{14 \times 10^6} = \boxed{4.8\%}$$