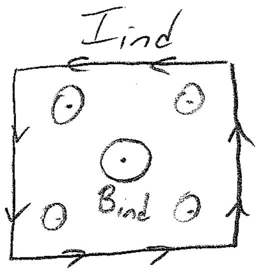
Physics 10164 - Exam 3A

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. <u>Clearly indicate your answer with a circle or a box</u> and remember to include correct <u>units</u> and <u>significant figures</u>.

1. (30 pts) A square loop is 15 cm on a side and has a resistance of 0.25 Ohms. There is a magnetic field piercing the loop with a magnitude of 3.5 Tesla pointing out of the page. The magnetic field switches directions so that it is pointing into the page in 63 milli-seconds. During this time interval, what is the magnitude and direction of the induced current in the loop?



Initial $\Phi = \odot$

$\Delta\Phi = \odot$, decreasing or

$\times$, increasing

Either way, B_{ind} points $\odot$

so I_{ind} = ccw

$$\mathcal{E}_{ind} = N\frac{\Delta\Phi}{\Delta t} = (1)\frac{(3.5)(.15)^2(2)}{.063}$$ ← $\Delta\cos\theta$

$= 2.5\ V$

$$I_{ind} = \frac{2.5}{0.25} = \boxed{10\ A}\ \boxed{ccw}$$

2. (20 pts) A DC circuit has a 3.0 Ohm resistor and a 0.024 H inductor and an emf of 12 Volts.

a) What is the time constant of this circuit?

b) What is the voltage drop across the inductor after 1.5 time constants have passed from the time the circuit is closed?

a) $\tau_L = \frac{L}{R} = \frac{.024}{3} = \boxed{.0080\ s}$

b) $\Delta V_L = \mathcal{E}_{max}\, e^{-t/\tau_L}$

$= 12 e^{-1.5} = \boxed{2.7\ V}$

c) $\Delta V_R = 12 - 2.7 = \boxed{9.3\ V}$

3. (30 pts) An RLC circuit has a voltage source with an rms voltage of 120 Volts, a 0.350 H inductor, and a 21 μF capacitor.

When this circuit is operating at the resonant frequency, what is the rms current? $R = 7.5\ \Omega$.

When this circuit is operating at 85% of the resonant frequency, what is the rms current?

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = 58.7\ Hz$$

a) When $f = f_0$, $Z = R$

$$I_{rms} = \frac{\mathcal{E}_{rms}}{Z} = \frac{120}{7.5} = \boxed{16\ A}$$

---

b) $f = (.85)(58.7) = 49.9\ Hz$

$$X_L = 2\pi(49.9)(.350) = 109.7\ \Omega$$

$$X_C = \frac{1}{2\pi(49.9)(21\times10^{-6})} = 151.8\ \Omega$$

$$Z = \sqrt{7.5^2 + (-42.2)^2} = 42.8\ \Omega$$

$$I_{rms} = \frac{120}{42.8} = \boxed{2.8\ A}$$

4. (20 pts) A transformer at a power plant steps up the generator voltage from 35,000 Volts to 240,000 Volts, and it delivers 3.0 Megawatts over power lines with a resistance of 450 Ohms.

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

$$(240{,}000\ V)(I_{wire}) = 3.0 \times 10^6\ W$$

$$I_{wire} = 12.5\ A$$

$$P_{loss} = I_{wire}^2 R = 70{,}300\ W$$

$$\% = \frac{P_{loss}}{P_{tot}} \times 100 = \boxed{2.3\%}$$