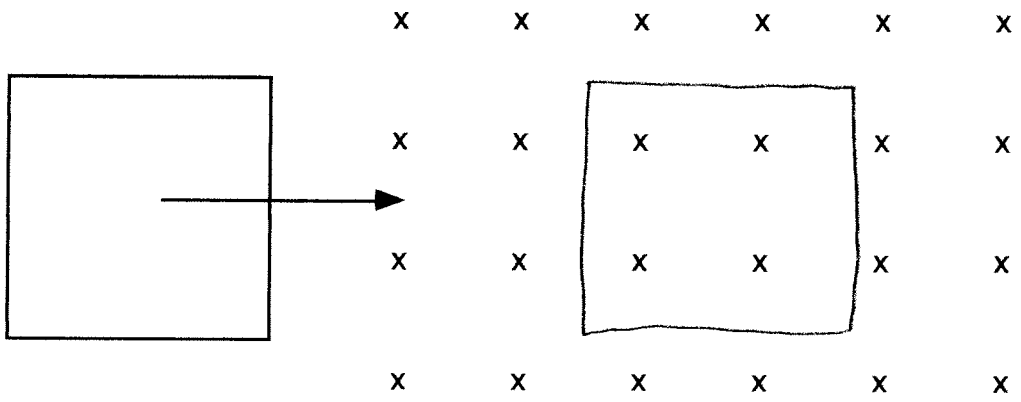
Physics 10164 - Exam 3C

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) A 250-turn square loop with a resistance of 0.38 Ohms, 25 cm on a side moves into a region of a uniform 2.2 Tesla magnetic field pointing into the page as shown below. It takes 0.44 sec for the loop to fully enter the field. During that time interval, find the magnitude and direction of the induced current in the loop. For the direction of current, be sure to explain your reasoning fully.



$\Phi_i = 0$

$\Phi_f = NBA\cos\theta$

$= (250)(2.2)(0.25)^2(1) = 34.375$

$\Delta t = 0.44\,s$

$\mathcal{E}_{ind} = \frac{\Delta\Phi}{\Delta t} = \frac{34.375}{0.44} = 78\ Volts$

$I_{ind} = \frac{\mathcal{E}_{ind}}{R} = \frac{78}{0.38} = \boxed{210\ A}$

$\Phi_i = 0$

$\Delta\Phi = X$, increasing

so $B_{ind} = \odot \Rightarrow I_{ind} = ccw$

2. (35 pts) A series AC circuit contains a 2.5 H inductor, a 15 μF capacitor and a 12 Ohm resistor connected to a 120 Volt rms source.

a) What is the power delivered to this circuit when it is operated at the resonant frequency?

b) What is the power delivered to this circuit when it is operated at one-half the resonant frequency?

a) At resonance, $Z = R = 12\ \Omega$

$$I_{rms} = \frac{\mathcal{E}_{rms}}{Z} = \frac{120}{12} = 10\ A$$

$$P = I\mathcal{E} = \boxed{1200\ W}$$

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b) $$f_{res} = \frac{1}{2\pi\sqrt{LC}} = 26\ Hz$$

$$f_{new} = 13\ Hz$$

$$X_L = 2\pi f L = 204\ \Omega$$

$$X_C = \frac{1}{2\pi f C} = 816\ \Omega$$

$$Z = \sqrt{12^2 + (816-204)^2} = 612\ \Omega$$

$$I_{rms} = \frac{120}{612} = 0.196\ A$$

$$P = I\mathcal{E} = \boxed{24\ W}$$

3. (30 pts) An AC power generator produces 75 Amps of current with a voltage of 3600 Volts fed into the 25 coil secondary input of a transformer. The voltage is stepped up to 72,000 Volts and the energy transmitted with this voltage through a power line with a resistance of 15 Ohms.

a) How many coils are in the primary output part of the transformer?

b) If the power is transmitted at the original 3600 Volt potential, what fraction of this supplied power is lost as heat dissipated by the power line?

c) If the power is transmitted at 72,000 Volts, what fraction of the supplied power is lost as dissipated heat?

a)

Primary	Secondary
$N_1 = ?$	$N_2 = 25$
$I_1 = ?$	$I_2 = 75\,A$
$\Delta V_1 = 72{,}000\,V$	$\Delta V_2 = 3600\,V$

$$\Delta V_1 = \frac{N_1}{N_2}\Delta V_2$$

$$72000 = \frac{N_1}{25}(3600) \qquad N_1 = \frac{(25)(72000)}{3600} = \boxed{500}$$

b) $P_{lost} = I_2^2 R = (75)^2(15) = 84375$

$P_{supp} = I_2 \Delta V_2 = (75)(3600) = 270000$

$$\frac{P_{lost}}{P_{supp}} = \boxed{31\%}$$

c) $I_1 \Delta V_1 = I_2 \Delta V_2 \qquad I_1 = \frac{(75)(3600)}{72000} = 3.75$

$P_{lost} = I^2 R = 211\,W$

$$\frac{P_{lost}}{P_{supp}} = \boxed{.078\%}$$