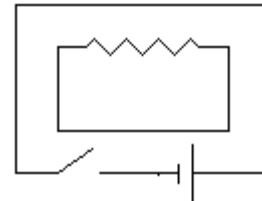


**Possibly Useful Information:**  $\mu_0 = 4\pi \times 10^{-7} \text{N/A}^2$ ,  $\epsilon_0 = 8.85 \times 10^{-12} \text{C}^2/(\text{N}\cdot\text{m}^2)$ ,  $e = 1.60 \times 10^{-19} \text{C}$ ,  $c = 3.00 \times 10^8 \text{m/s}$

**Problem 1** Multiple Choice (3 points each)

\_\_\_\_\_ [i] A car drives to the east in the earth's magnetic field, which points to the north. Where on the car is the voltage the highest? (a) top (b) bottom (c) front (d) back (e) left (g) right

\_\_\_\_\_ [ii] What is the direction of the current through the resistor when the switch is closed and then opened? (a) left then left (b) left then right (c) right then left (d) right then right (e) cannot be determined



\_\_\_\_\_ [iii] A series RCL circuit is driven at a frequency above its resonance frequency. What is the sign of the phase angle? (a)  $\phi < 0$  (b)  $\phi = 0$  (c)  $\phi > 0$  (d) It cannot be determined.

\_\_\_\_\_ [iv] Suppose an isolated magnetic north pole is discovered and then dropped through a horizontal conducting loop. What is the direction of the induced current in the current in the loop as the pole enters and then exits the loop? (a) clockwise then counterclockwise (b) clockwise then clockwise (c) counterclockwise then counterclockwise (d) counterclockwise then clockwise (e) cannot be determined

\_\_\_\_\_ [v] A transformer is connected to a standard outlet. Suppose the primary coil has 200 turns and carries an rms current of 4A. If the secondary coil has 400 turns, then what is the rms voltage and rms current in the secondary coil? (a) 60V and 2A (b) 60V and 4A (c) 60V and 8A (d) 120V and 2A (e) 120V and 4A (f) 120V and 8A (g) 240V and 2A (h) 240V and 4A (i) 240V and 8A

**Problem 2** A solenoid has a radius of 2cm, 300 turns and a length of a 90cm (6 points each)

(a) If this solenoid carries a 4A current. What is the energy stored in the solenoid?

(b) If this solenoid sits with its central axis aligned vertically in an upward magnetic field that *decreases* at a rate of 7T/s, then what is the induced emf in the solenoid? Also give the direction of the induced EMF as clockwise or counterclockwise as viewed from above.

(c) Suppose this solenoid is initially aligned with a 20mT magnetic field and then rotated with a frequency of 20Hz about an axis perpendicular to the field. What is the rms voltage across the solenoid?

**Problem 3** Consider a  $18\Omega$ , a  $30\mu\text{F}$  capacitor and a  $50\text{mH}$  inductor. (6 points each)

(a) What is the peak current when just the inductor is connected across a standard outlet?

(b) What is the rms current when just the resistor and capacitor are connected in series across an AC source with an rms voltage of  $4\text{V}$  and a frequency of  $100\text{ Hz}$ ?

(c) What is the average power dissipated in the circuit in part (b)?

(d) Suppose the capacitor is given a charge of  $5\ \mu\text{C}$  and connected across the resistor. How long does it take for the charge to reach  $1\ \mu\text{C}$ ? (Only the capacitor and resistor are connected here.)

(e) Suppose the capacitor is given a charge of  $5\mu\text{C}$  and connected across the inductor. What is the peak current through the inductor? (Only the capacitor and inductor are connected here.)

(f) Suppose the resistor, capacitor and inductor are connected in series across a variable frequency source with fixed rms voltage of  $4\text{V}$ . At what frequency is the current a maximum and what is the maximum rms current?

**Problem 4** At a distance of 20m from an isotropic 100 MHz radio source the intensity is  $80\text{W/m}^2$ .

(6 points each)

(a) What is the rms electric field at 20m?

(b) Over a 2 hour period, what is the momentum given to a  $4\text{cm}\times 4\text{cm}$  surface (at the 20m distance) perpendicular to the source that reflects  $\frac{3}{4}$  of the energy?

(c) What is the power transmitted by the source?

(d) What is the wavelength of the source?

**Problem 5** What is the mutual inductance between the long wire and the single-turn rectangular loop shown? (7 points)

