

Name: _____

12/1/10

Present neat and orderly answers for each question.

Clearly indicate your method of solution for each problem, including equations used.

Include appropriate units.

Show all work.

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$\mu_0 = 1.26 \times 10^{-6} \text{ Tm/A}$$

Make sure your calculator is in the correct mode!

Multiple Choice (2 pts each)

1. A current is induced in a conducting loop that lies in a horizontal plane, and the induced current is clockwise when viewed from above. Which of the following statements is true regarding the induced current?
- A constant magnetic field is directed vertically downward.
 - A constant magnetic field is directed vertically upward.
 - A magnetic field whose magnitude is decreasing is directed vertically downward.
 - A magnetic field whose magnitude is decreasing is directed vertically upward.

Ans. _____

2. Which of the following statements is false regarding the following situations related to magnetic fields?
- The induced emf in a circuit is equal to the negative of the magnetic flux through the circuit.
 - There can be a nonzero induced emf at an instant when the flux through the circuit is equal to zero.
 - The self-induced voltage of a solenoid is proportional to the rate of change of the current in the solenoid.
 - The magnetic energy density at some point in space is proportional to the square of the magnitude of the magnetic field at that point.

Ans. _____

3. If the rms voltage in an ac circuit is doubled, the peak voltage is:
- doubled;
 - halved;
 - increased by a factor of $\sqrt{2}$;
 - not changed.

Ans. _____

4. Consider a circuit consisting solely of an ideal inductor and an ideal capacitor. How does the maximum energy stored in the capacitor compare to the maximum energy stored in the inductor?
- They are the same and each is equal to the total energy stored in the circuit.
 - They are the same and each is equal to half the total energy stored in the circuit.
 - The maximum energy stored in the capacitor is larger than the maximum energy stored in the inductor.
 - You cannot compare the maximum energies based on the data given, because the ratio depends on the actual capacitance and inductance values.

Ans. _____

5. An ideal transformer has N_1 turns on its primary and N_2 turns on its secondary. The average power delivered to a load resistance R connected across the secondary is P_2 when the primary rms voltage is V_1 . The rms current in the primary windings can be written as:

a. $2\left(\frac{N_2}{N_1}\right)\left(\frac{P_2}{V_1}\right)$;

b. $\left(\frac{N_2}{N_1}\right)\left(\frac{P_2}{V_1}\right)$;

c. $\left(\frac{N_1}{N_2}\right)\left(\frac{P_2}{V_1}\right)$;

d. $\frac{P_2}{V_1}$.

Ans. _____

6. A circuit containing a capacitor has a source of time-varying emf that provides a voltage given by $v_c(t) = V\sin(\omega t)$. What is the current i_c , through the capacitor when the potential difference across it is largest ($v_c = V_{\max}$)?

a. $I_c = 0$;

b. $I_c = +I_{\max}$;

c. $I_c = -I_{\max}$;

d. Cannot be determined from the information given.

Ans. _____

7. A rectangular loop of wire is pulled at constant acceleration from a region of zero magnetic field into a region of uniform magnetic field (directed perpendicular to the plane containing the wire loop), where the loop is completely immersed in the magnetic field. During this process, the current induced in the loop

a. will be zero;

b. will be a constant non-zero value;

c. will increase linearly with time;

d. will increase linearly with the square of time.

Ans. _____

8. A series RLC circuit contains a source voltage, where $v(t) = V\sin(\omega t)$. If the voltage $v(t)$ is increasing in time during a specified time interval, how is the current behaving?

a. The current is constant;

b. The current is increasing;

c. The current is decreasing;

d. Not enough information, the current may be increasing or decreasing.

Ans. _____

9. Which of the following is true regarding electromagnetic waves?

a. The electric and magnetic fields are parallel to each other;

b. The direction of propagation is perpendicular to the magnetic field;

c. The speed of light is directly proportional to ϵ_0 and μ_0 ;

d. The rate of flow of energy in an electromagnetic wave is a scalar quantity.

Ans. _____

10. Which of the following statements would be true regarding a situation where you very quickly remove a plug, connected to an appliance that is currently turned on, from an outlet?

a. The appliance would turn off, with no additional effects.

b. The appliance would turn off, and a small voltage is induced causing a small spark.

c. The appliance would turn off, and a large voltage is induced causing a large spark.

d. The appliance would remain on due to the large induced voltage.

Ans. _____

Problem 1 (20 pts)

A square loop of wire of N turns, located in the plane of the page, is traveling at a constant velocity v in the $+x$ -direction. The square loop begins outside of the region containing the magnetic field and will begin entering the region containing the magnetic field at $t = 0$. A time varying magnetic field that varies as $\vec{B}(t) = \alpha t^2$, where α is a constant, B is measured in Teslas and t is measured in seconds, is directed in the $+z$ -direction (out of the page).

- a) Determine an expression for the magnetic flux as a function of time. (6 pts)
- b) Determine an expression for the induced current as a function of time, if the coil has a resistance R . (6 pts)
- c) Calculate the magnitude and determine the direction of the induced current when $t = 5$ s. Use the following information $L = 10$ cm, $v = 4$ m/s, $R = 50 \Omega$, $\alpha = 200$ T/s² and $N = 20$ turns. (4 pts)
- d) Plot the current vs. time. Make sure to determine and label the graph with any noteworthy current values. (4 pts)

Problem 2 (20 pts)

A series RLC circuit has a voltage source that supplies a voltage, $V(t) = 40\sin(100t - \pi/3)$. The circuit has a resistance of 60Ω , an inductance of 200 mH and a capacitance of $80 \mu\text{F}$.

- a) Determine the impedance of the circuit. (2 pts)
- b) Determine the phase between the current and the voltage. (4 pts)
- c) Determine the value of the current and the voltage at $t = 10 \text{ ms}$. (4 pts)
- d) Draw a phasor diagram for this circuit at $t = 0$. Clearly indicate the voltage across the resistor, the voltage across the inductor, the voltage across the capacitor, the source voltage, the resulting current and all appropriate angles. Indicate the amplitude of the voltages and currents on the diagram. (10 pts)

