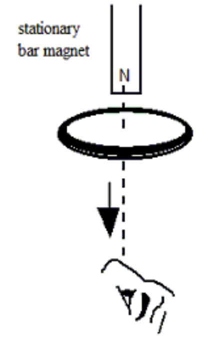
AP Physics C   Name: ________________________________

Unit 6 Test: EMI

Part 1: Multiple Choice - Choose the answers that best answers the questions below. If an exact answer is not present, chose the closest available answer. (4 points each)

1. A metal ring is dropped from rest below a bar magnet that is fixed in position as suggested in the figure. An observer views the ring from below. Which one of the following statements concerning this situation is true?

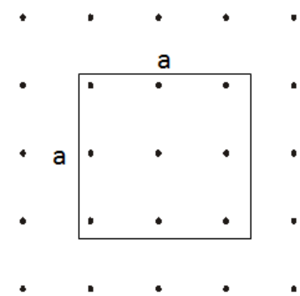


   A) As the ring falls, an induced current will flow *counterclockwise* as viewed by the observer.
   B) As the ring falls, an induced current will flow *clockwise* as viewed by the observer.
   C) As the ring falls, there will be an induced magnetic field around the ring that appears *counterclockwise* as viewed by the observer.
   D) As the ring falls, there will be an induced magnetic field around the ring that appears *clockwise* as viewed by the observer.
   E) Since the magnet is stationary, there will be no induced current in the ring.

2. A square loop of copper wire is initially placed perpendicular to the lines of a constant, uniform magnetic field of 5.0×10^{-3} T. The area enclosed by the loop is 0.2 m^2. The loop is then turned through an angle of 90° so that the plane of the loop is parallel to the field lines. The turn takes 0.1 second. The average emf induced in the loop during the turn is

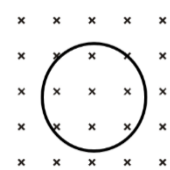
   A) 1.0×10^{-4} V   B) 2.5×10^{-3} V   C) 0.01 V   D) 100   E) 10 V

3. A square conducting loop with side $a = 0.5\ m^2$ and resistance R = 2 Ω is held in a magnetic field given by $B(t) = 8 - 4t$. The current induced in the loop is:



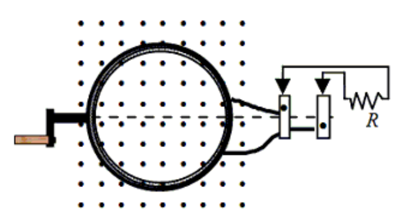
   A) Zero
   B) 1 A, clockwise
   C) 1 A, counterclockwise
   D) 0.5 A, clockwise
   E) 0.5 A, counter-clockwise

4. A wire loop of area A is placed in spatially uniform magnetic field that is perpendicular to the plane of the loop. The induced emf in the loop is given by $\varepsilon(t) = kA\sqrt{t}$, where k is a constant. Which expression below gives the magnetic field as a function of time?

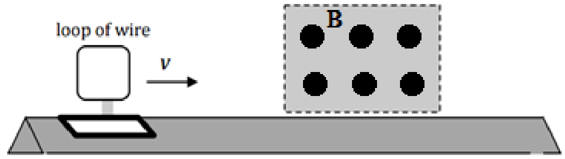


   $\frac{kA\sqrt{t}}{2t}$ B) $\frac{k\sqrt{t}}{2t}$ C) $\frac{k\sqrt{t}}{2}$ D) $\frac{2kAt^{\frac{3}{2}}}{3}$ E) $\frac{2kt^{\frac{3}{2}}}{3}$

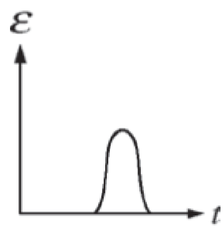
5. A circular coil has 275 turns and a radius of 0.045 m. The coil is used as an ac generator by rotating it in a 0.500 T magnetic field, as shown in the figure. At what angular speed should the coil be rotated so that the maximum emf is 175 V?



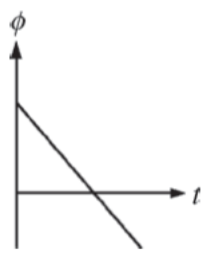
   A) 28 rad/s   B) 50 rad/s   C) 130 rad/s
   D) 200 rad/s   E) 490 rad/s

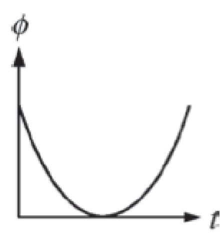


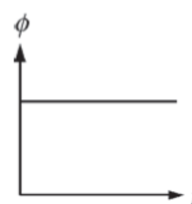
6. A single, continuous loop of conducting wire is mounted on a glider, which travels on a frictionless air track with an initial velocity v. When the **front edge** of the loop enters the magnetic field B pointing out of the page as shown:
   A) there is a clockwise current in the loop, and the glider slows down.
   B) there is a counterclockwise current in the loop, and the glider slows down.
   C) there is a clockwise current in the loop, and the glider speeds up.
   D) there is a counterclockwise current in the loop, and the glider speeds up.
   E) there is no current in the loop, and the glider travels at constant v.

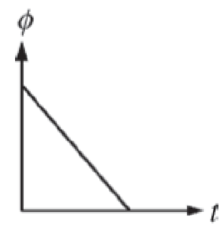


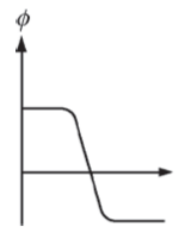
7. The graph above shows an emf ε induced in a loop of wire as a function of time t. Which of the following graphs best corresponds to the magnetic flux passing through the loop of wire as a function of time, t.

A) 

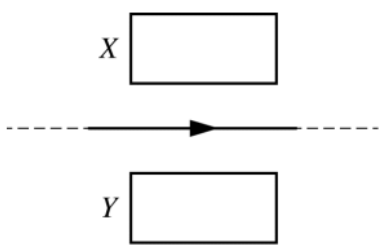
B) 

C) 

D) 

E) 

8. Two identical rectangular conducting loops and a long wire lie in the plane of this page, as shown. The loops are equal distances from the wire.



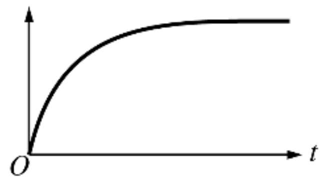
If the current in the wire is constant, and the wire is moved towards loop X, what is the direction of the induced current, if any, in each of the loops?

A) Loop X – None   Loop Y - None
B) Loop X – Counterclockwise   Loop Y - Clockwise
C) Loop X – Clockwise   Loop Y - Counterclockwise
D) Loop X – Counterclockwise   Loop Y - Counterclockwise
E) Loop X – Clockwise   Loop Y - Clockwise

9. An emf of 0.8 V is induced in the windings of a coil when the current in a nearby coil is increasing at the rate of 2.4 A/s. What is the mutual inductance of the two coils?

A) 0.3 H B) 0.7 H C) 1.9 H D) 7.2 H E) 3.0 H

10. A circuit consists of a resistor of resistance R, an inductor of inductance L, and open switch connected with a battery. The switch is closed at time t = 0.

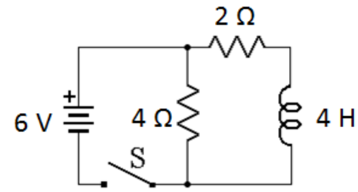


Which of the following quantities could be represented by the graph shown above?

I. The potential difference across the resistor, R.
II. The potential different across the inductor.
III. The current through the resistor.

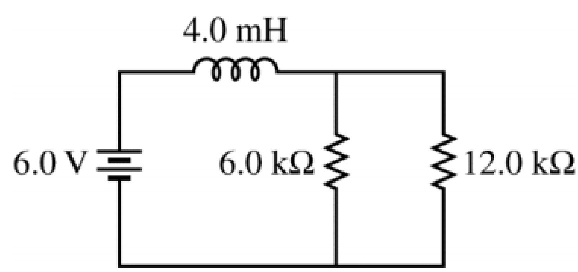
A) I only B) I & II C) I & III D) II & III E) I, II & III

11. In the circuit shown, the switch is closed for a long time. What is the energy stored in the inductor?



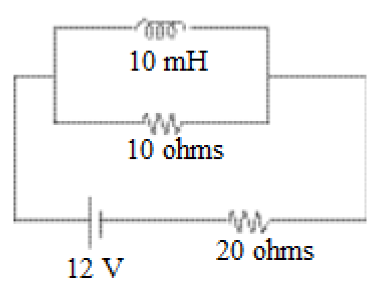
A) 8 J B) 12 J C) 18 J D) 27 E) 36 J

12. An inductor and two resistors are connected to an ideal battery as shown. What is the time constant for the circuit?



A) 0.22 μs
B) 0.33 μs
C) 0.67 μs
D) 1.0 μs
E) 72 μs

13. For the circuit shown, what is the rate of change of the current in the inductor when the current in the battery is 0.50 A?



A) 600 A/s
B) 400 A/s
C) 200 A/s
D) 800 A/s
E) 0 A/s

14. The number of lööps in a solenoid is increased to twice its original value while the length is kept constant. Which one of the following statements is true concerning the self-inductance of the solenoid?

A) The self-inductance does not change.
B) The self-inductance increases by a factor of two.
C) The self-inductance decreases by a factor of two.
D) The self-inductance increases by a factor of four.
E) The self-inductance decreases by a factor of four.

15. James Maxwell used four equations to describe all electric and magnetic phenomena. Which of the following is not a consequence of one of Maxwell's equations?

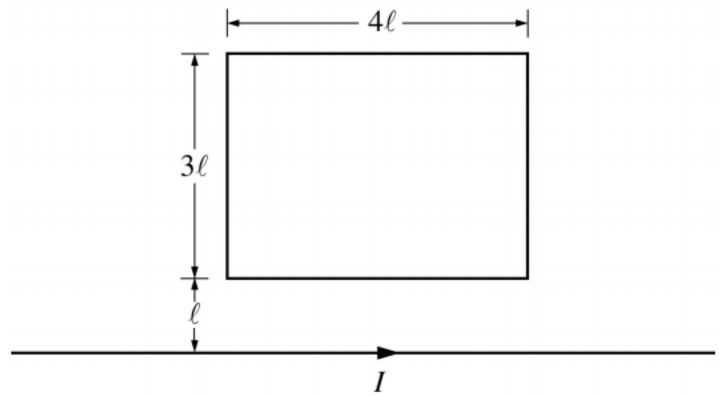
A) The magnetic force on a charged particle is equal but opposite to the electric force on it.
B) An isolated monopole cannot exist.
C) Charges create electric fields in the space around them.
D) An electric current and a changing electric field create a magnetic field.
E) A changing magnetic field creates an electric field.

Multiple Choice Answers:

1. _______	6. _______	11. _______
2. _______	7. _______	12. _______
3. _______	8. _______	13. _______
4. _______	9. _______	14. _______
5. _______	10. ______	15. _______

Part 2: Free Response. You must show all steps required to arrive at the correct answer for the problem below, including any diagrams. **All answers must be given with correct units.**

16. (10 points) A rectangular loops of dimension $3l$ and $4l$ lies in the plane of the page as shown. A long straight wire also in the plane of the page carries a current I.



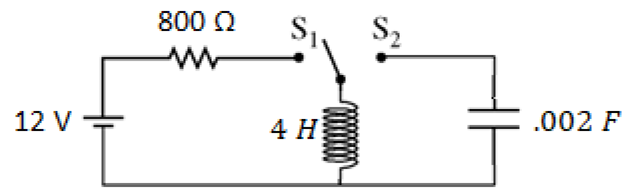
a) Calculate the magnetic flux through the rectangular loop.

b) Starting at time t = 0, the current in the straight wire is given by $I(t) = I_0 e^{-Ct}$, where I_0 and C are constants.

i. What direction is the current induced in the loop?

ii. Determine an expression for the current in the loop as a function of time if the loop has a total resistance of R.

17. (14 points) An LC circuit is set up as shown. At time t = 0, the switch is set to position S1.



a) Calculate the time for the voltage across the resistor to reach -6 V.

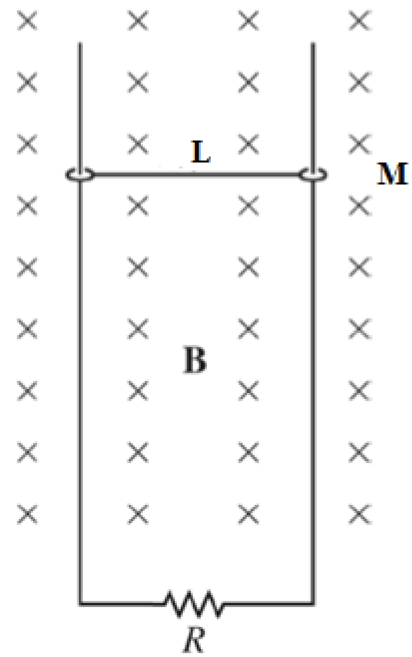
b) After oh so long, the switch is set to position S2.

i. Explain why the circuit will oscillate.

ii. Set up a differential equation to determine the charge q, in the capacitor once the switch is flipped. Use your equation to determine the period of oscillation of the LC circuit.

iii. Determine the range of change of current in the inductor when the capacitor has 14 mC of charge.

18. (18 points) A bar of mass M and length L is connected to two long vertical frictionless rails. They are placed in a uniform magnetic field of magnitude B direction into the plane of this page as shown. The bottom of the rails are connected to a resistor of resistance R. The bar is released from rest in the position shown.



a) Indicate the magnitude of the current in the resistor.

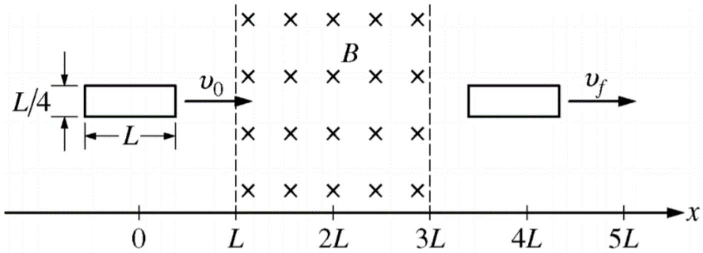
b) At a certain time, T, the bar is falling with speed V and has not yet reached terminal velocity. Determine the power dissipated in the circuit at T.

c) At some time before leaving the magnetic field, the bar reaches a terminal velocity. Determine this terminal velocity.

d) Write, but do not solve a differential equation for the velocity of the falling bar while it is in the magnetic field.

e) How would the force on the bar as its falling change if the resistance of the resistor is decreased? Justify your answer.

Bonus:



The rectangular loop of wire shown on the left in the figure above has mass M, length L, width $L/4$, and resistance R. It is initially moving to the right at constant speed v_0, with no net force acting on it. At time $t = 0$ the loop enters a region of length $2L$ that contains a uniform magnetic field of magnitude B directed into the page. The loop emerges from the field at time t_f with final speed v_f. Express all algebraic answers to the following in terms of M, L, R, B, v_0, and fundamental constants, as appropriate.

Write, but do not solve, a differential equation for the speed v as a function of time as the loop enters the field.