

**AP Physics**  
**Test - Serway (5th) - Ch. 31, 32**

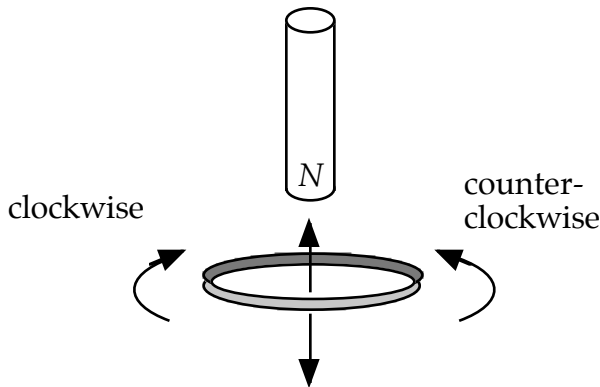
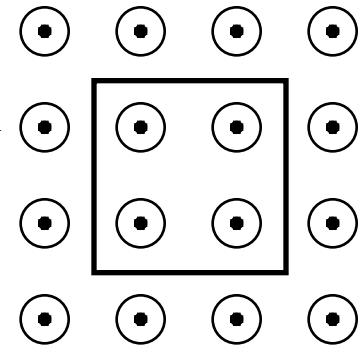
**Faraday's Law; Inductance**

**Part I. Multiple Choice (5 points each)**

Choose the one best answer to each of the following problems.

1 (AP). A square loop of wire of side 0.5 meter and resistance  $10^{-2}$  ohms is located in a uniform magnetic field of intensity 0.4 tesla directed out of the page as shown here. The magnitude of the field is decreased to zero at a constant rate in 2 seconds. As the field is decreased, what are the magnitude and direction of the current in the loop?

- a. Zero  
 b. 5 A, counterclockwise  
 c. 5 A, clockwise  
 d. 20 A, counterclockwise  
 e. 20 A clockwise



2 (AP). In the figure here, the north pole of the magnet is first moved down toward the loop of wire, then withdrawn upward. As viewed from above, the induced current in the loop is:

- a. always clockwise with increasing magnitude  
 b. always clockwise with decreasing magnitude  
 c. always counterclockwise with increasing magnitude  
 d. always counterclockwise with decreasing magnitude  
 e. first counterclockwise, then clockwise

3. A planar loop consisting of four turns of wire, each of which encloses  $200 \text{ cm}^2$ , is oriented perpendicularly to a magnetic field that increases uniformly in magnitude from 10 mT to 25 mT in a time of 5.0 ms. What is the resulting induced current in the coil if the resistance of the coil is  $5.0 \Omega$ ?

- a. 60 mA  
 b. 12 mA  
 c. 0.24 mA  
 d. 48 mA  
 e. 6.0 mA

4. A conducting bar (length = 15 cm) rotates in the  $xy$  plane with one end pivoted at the origin. The bar rotates at a constant angular speed and completes 20 rotations per second. A uniform 50-mT magnetic field is directed in the positive  $z$  direction. What is the magnitude of the emf induced between the ends of the bar?

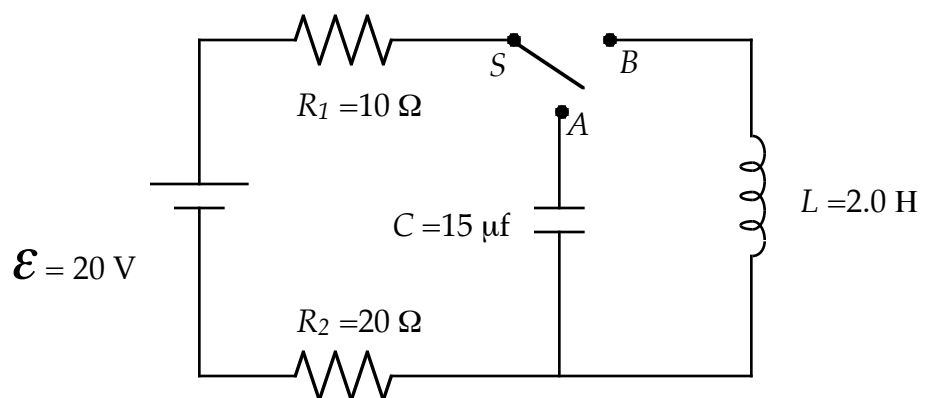
- a. 23 mV  
 b. 11 mV  
 c. 0.14 mV  
 d. 71 mV  
 e. 140 mV

**Part II. Free Response (15 points each)**

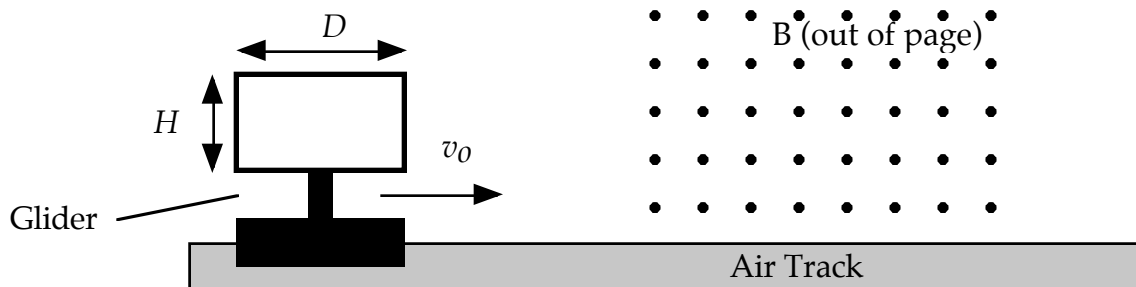
5 (AP). In the circuit shown here, the switch  $S$  is initially in the open position shown, and the capacitor is uncharged. A voltmeter (not shown) is used to measure the correct potential difference across resistor  $R_1$ .

- a. On the circuit diagram above, draw the voltmeter with the proper connections for correctly measuring the potential difference across resistor  $R_1$ .

- b. At time  $t=0$ , the switch is moved to position  $A$ . Determine the voltmeter reading for the time immediately after  $t=0$ .



- c. After a long time, a measurement of potential difference across  $R_1$  is again taken. Determine for this later time each of the following.
- The voltmeter reading
  - The charge on the capacitor
- d. At a still later time  $t = T$ , the switch  $S$  is moved to position  $B$ . Determine the voltmeter reading for the time immediately after  $t = T$ .
- e. A long time after  $t = T$ , the current in  $R_1$  reaches a constant value  $I_f$ .
- Determine  $I_f$
  - Determine the final energy stored in the inductor.
- f. Write, but do not solve, a differential equation for the current in resistor  $R_1$  as a function of time  $t$  after the switch is moved to position  $B$ .



6 (AP).

The long narrow rectangular loop of wire shown above has vertical height  $H$ , length  $D$ , and resistance  $R$ . The loop is mounted on an insulated stand attached to a glider, which moves on a frictionless horizontal air track with an initial speed of  $v_0$  to the right. The loop and glider have a combined mass  $m$ . The loop enters a long narrow region of uniform magnetic field  $B$  directed out of the page toward the reader. Express your answers to the parts below in terms of  $B$ ,  $D$ ,  $H$ ,  $R$ ,  $m$ , and  $v_0$ .

a. What is the magnitude of the initial induced emf in the loop as the front end of the loop begins to enter the region containing the field?

b. What is the magnitude of the initial induced current in the loop?

c. State whether the initial induced current in the loop is clockwise or counterclockwise around the loop.

d. Derive an expression for the velocity of the glider as a function of time  $t$  for the interval after the front edge of the loop has entered the magnetic field but before the rear edge has entered the field.

e. Using the axes below, sketch qualitatively a graph of speed  $v$  versus time  $t$  for the glider. The front end of the loop enters the field at  $t=0$ . At  $t_1$  the back end has entered and the loop is completely inside the field. At  $t_2$  the loop begins to come out of the field. At  $t_3$  it is completely out of the field. Continue the graph until  $t_4$ , a short time after the loop is completely out of the field. These times may not be shown to scale on the  $t$ -axis below.

