Exam 2

Your Name:

Instructions

Solve each of the following problems to the best of your abilities. The exam is worth 100 points total and is calibrated for one class period. Once you have completed the exam, hand it to me, and you can leave for the day.

Good luck!

(25 points) A charging RC circuit is created by connecting a 10 V battery, a 0.05 F capacitor, a 200 Ω resistor, and a switch in series. You can assume that there is no initial charge stored on the capacitor. The switch is closed at time t = 0 seconds.

1. (7 points) What is the time constant of the circuit?

The time constant in this simple RC circuit is given by:

$$\tau = RC = (0.05\,F)(200\,\Omega) = 10\,s$$

2. (5 points) What is the voltage across the capacitor when the switch is closed (time t = 0 seconds)?

When the switch is first closed, there is no charge stored in the capacitor. Thus, the voltage across the capacitor is equal to:

$$V = \frac{Q}{C} = \frac{0\,C}{0.05\,F} = 0\,V$$

3. (5 points) What is the voltage across the capacitor when it is fully charged (after a long time)?

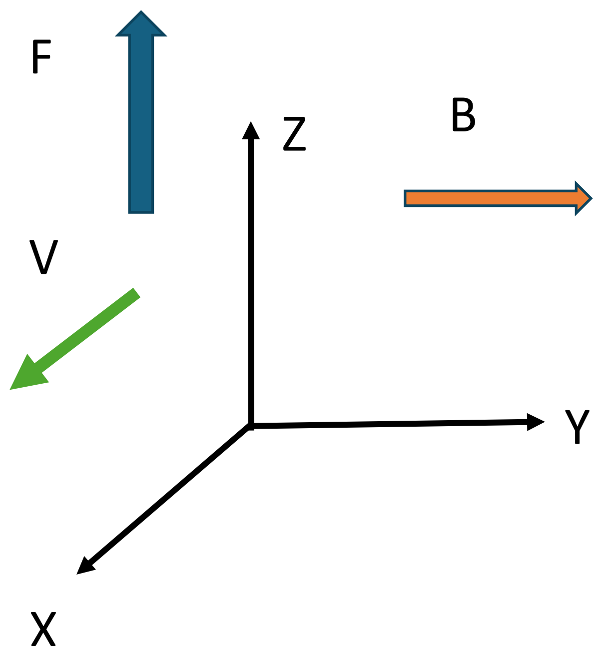
When the switch has been closed for a long time, the voltage across the capacitor is equal to the voltage across the battery and there is no current flowing in the circuit. V = 10 V.

4. (8 points) If I were to increase the resistance of the resistor, would you expect the capacitor to charge up faster, slower, or at the same rate? Why?

If you increase the resistance of the resistor, the time constant of the circuit would increase. In that situation, the capacitor would charge up at a slower rate. In other words, it would take longer to charge.

(27 points) A particle with a mass of m = 0.75 kg and a charge q = +0.27 C enters a region of uniform magnetic field with an initial velocity of v_o = 5 m/s in the +x direction. The strength of the magnetic field is B = 1.30 T, oriented in the +y direction.

1. (15 points) Draw a diagram of the system. Be sure to include and neatly label the following:
    a. The x-, y-, and z-directions (remember that we use a right-handed coordinate axis).
    b. The particle and its initial velocity vector.
    c. The magnetic field and its direction vector.
    d. The magnetic force vector acting on the particle.



2. (5 points) What is the magnitude of the magnetic force on the particle?

The magnitude of the force on the particle is given by:

$$F = qvB\sin\theta$$

Since the velocity and magnetic field are oriented 90 degrees with respect to each other, this simplifies to:

$$F = qvB$$

Plugging in values yields:

F = 1.76 N

3. (7 points) What is the period of the oscillations made by the particle?

From class, we learned that the radius of the particle's path can be found by setting the magnetic force equal to the centripetal force. This gives us:

$$r = \frac{mv}{qB}$$

The circumference of the circular path is given by 2πr:

$$C = 2\pi r = \frac{2\pi mv}{qB}$$

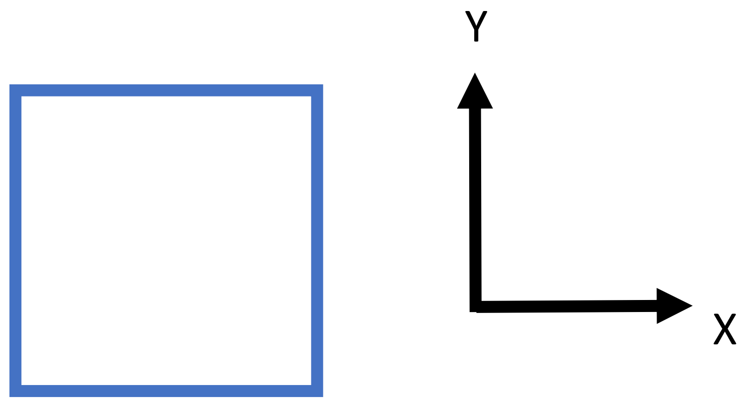
The period of the particle is then the circumference of the path divided by the speed at which the particle moves:

$$T = \frac{C}{v} = \frac{2\pi m}{qB}$$

Putting it all together, we get:

T = 13.43 sec

(30 points) A square loop of wire with a side length of 0.50 meters is oriented in the XY plane as shown in the figure below. The loop carries a current of 0.39 A in the clockwise direction. A uniform magnetic field of 0.21 T is oriented in the +x direction.



1. (6 points) What is the magnetic force on the left side of the loop (magnitude and direction)?

$$F = BIL\sin\theta$$

$$F = (0.21\ T)(0.39\ A)(0.50\ m)\sin(90°)$$

$F = 0.041\ N$ (Into the page)

2. (6 points) What is the magnetic force on the top of the loop (magnitude and direction)?

$$F = BIL\ \sin\theta$$

$$F = (0.21\ T)(0.39\ A)(0.50\ m)\sin(0°)$$

$$F = 0\ N$$

3. (6 points) What is the magnetic force on the right side of the loop (magnitude and direction)?

$$F = BIL\ \sin\theta$$

$$F = (0.21\ T)(0.39\ A)(0.50\ m)\sin(90°)$$

$F = 0.041\ N$ (Out of the page)

4. (6 points) What is the magnetic force on the bottom of the loop (magnitude and direction)?

$$F = BIL \sin\theta$$

$$F = (0.21\,T)(0.39\,A)(0.50\,m)\sin(0°)$$

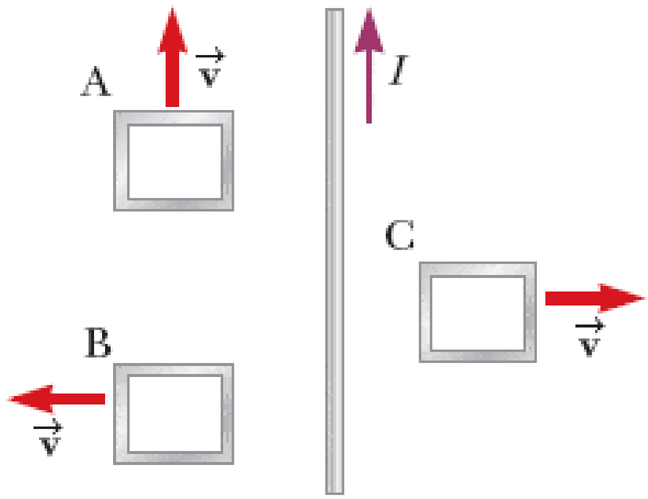
$$F = 0\,N$$

5. (6 points) What is the net force on the loop?

The net force is given by:

$$F = +0.041\,N - 0.041\,N + 0\,N + 0\,N = 0\,N$$

(18 points) Three loops (A, B, and C) are positioned next to a long, straight wire carrying current in the upward direction. Each of the loops moves with a constant velocity in the direction indicated by the red arrows. Assume that the area vector of each loop is pointing out of the page.



1. (2 points) What is the direction of the magnetic field from the long, straight wire within loop B?
   a. Into the page
   b. Out of the page
   c. Left
   d. Right
   e. Up
   f. Down

2. (2 points) What is the direction of the magnetic field from the long, straight wire within loop C?
   a. Into the page
   b. Out of the page
   c. Left
   d. Right
   e. Up
   f. Down

3. (3 points) How is the magnetic flux changing in loop A as it moves?
    a. Increasing
    b. Decreasing
    c. Staying the Same

4. (3 points) How is the magnetic flux changing in loop B as it moves?
    a. Increasing
    b. Decreasing
    c. Staying the Same

5. (4 points) What is the direction of the induced current in loop A?
    a. Clockwise
    b. Counterclockwise
    c. No Current

6. (4 points) What is the direction of the induced current in loop C?
    a. Clockwise
    b. Counterclockwise
    c. No Current