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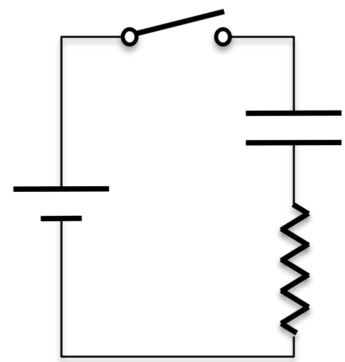
last *first*

Questions 1 - 3 concern the circuit shown at right that contains a resistor (R = 200 Ω) and a capacitor (C = 240 nF) and an ideal 12 V batter.



1. **Immediately after** the switch is closed, what is the potential difference across the capacitor?

   A. V_C = 0 V.

   B. V_C = 2.40 x 10^{-9} V.

   C. V_C = 6 V.

   D. V_C = 12 V.

2. **Immediately after** the switch is closed, what is the current through the resistor?

   A. I_R = 0 A.

   B. I_R = 27 mA.

   C. I_R = 60 mA.

   D. I_R = 200 mA.

3. **A long time after** the switch has been closed, what is the charge on the capacitor?

   A. Q_C = 2.88 x 10^{-6} C.

   B. Q_C = 2.40 x 10^{-7} C.

   C. Q_C = 2.00 x 10^{-8} C.

   D. Q_C = 0.

---

4. A positively charged particle has an initial velocity of unknown magnitude and direction when it enters a region in which there is a uniform electric field E = 2000 V/m in the -z direction and a uniform magnetic field B = 0.2 T in the -y direction. The particle's velocity is **not affected** by the fields. What is its velocity?

   A. 1.0 x 10^4 m/s in the +y direction

   B. 1.0 x 10^4 m/s in the -x direction

   C. 1.0 x 10^{-4} m/s in the +x direction

   D. 1.0 x 10^{-4} m/s in the -x direction

   E. 1.0 x 10^{-4} m/s in the +z direction

Name ____________________________________ **Student ID** ________________
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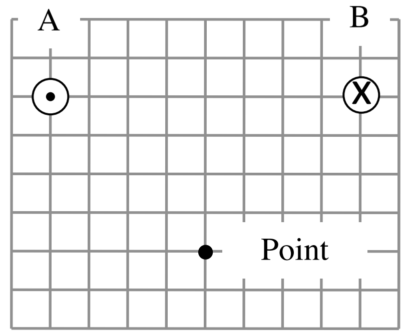
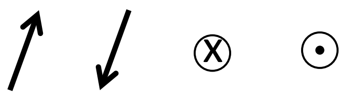


Questions 5 and 6 concern the current-carrying wires shown at right. Wire A carries current I_A out of the page; wire B carries current I_B into the page. $I_A = 2I_B$.

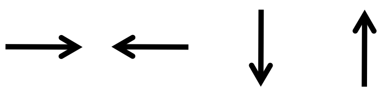
5. Which arrow below best represents the direction of the magnetic field at point X?



other

A B C D E

6. Which arrow below best represents the direction of the force exerted on wire B by wire A?



other

A B C D E

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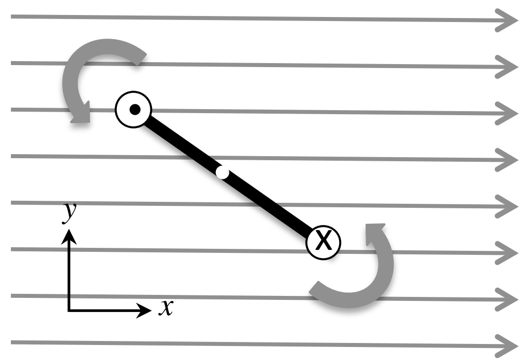
Questions 7 - 9 concern a conducting loop in a uniform magnetic field directed along the +x-axis, as shown in the **side-view** diagram at right. **At the instant shown** the loop is rotating with a constant angular velocity ω about an axis along the z-axis through the loop's center.

For question 7, the loop is carrying a current (produced by a battery) in the direction indicated (out of the page at the top of the loop). For questions 8 and 9, the loop is not carrying a current produced by a battery.



Side-view diagram

7. (**With** current from a battery.) **At the instant shown** is potential energy U increasing, decreasing or remaining constant?

   A. U is increasing.

   B. U is decreasing.

   C. U is not zero, and remaining constant.

   D. U is zero, and remaining constant.

8. (**Without** current from a battery.) **At the instant shown**, is the absolute value of the rate of change of the magnetic flux through the loop $\left|\frac{d\Phi}{dt}\right|$ increasing, decreasing, or constant?

   A. $\left|\frac{d\Phi}{dt}\right|$ is increasing.

   B. $\left|\frac{d\Phi}{dt}\right|$ is decreasing.

   C. $\left|\frac{d\Phi}{dt}\right|$ is not zero, and remaining constant.

   D. $\left|\frac{d\Phi}{dt}\right|$ is zero, and remaining constant.

9. (**Without** current from a battery.) Assuming the loop has a single turn, area A and total resistance R, the B-field has magnitude B_0 and at the instant shown the angle between the loop and the B-field is 45°, what is the magnitude of the induced current i?

   A. $\frac{BA\omega}{\sqrt{2}R}$

   B. $\frac{BA}{\sqrt{2}R}$

   C. $\frac{BA\omega}{\sqrt{2}}$

   D. There is no induced current.

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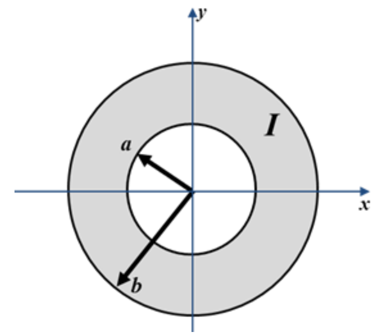
III. [25 pts] Parts A and B are independent.

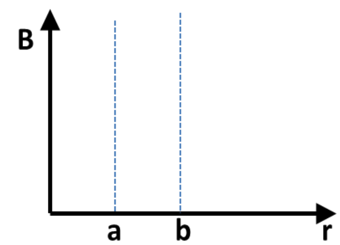
PART A: An infinitely long cylindrical shell with inner radius **a** and outer radius **b** carries a uniformly distributed current **I** out of the page.

Determine **B** in the three regions listed below and explain or support your reasoning with words or calculation.



1. r < a

2. a < r < b

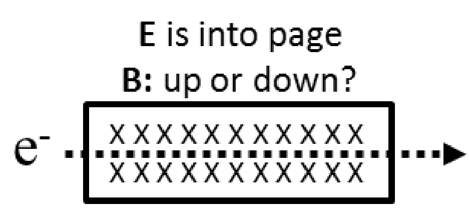


3. r > b

4. Sketch |B| as a function of **r**.

PART B: See sketch. A beam of electrons passes undeflected through the a region which contains a uniform electric field of 10 N/C into the page and a uniform magnetic field of 2×10^{-4} T perpendicular to its path and to the electric field orientation.

What is the speed of the electrons through this region and which way does the B field point?



v_e = __________ m/s

B is (circle one): UP DOWN