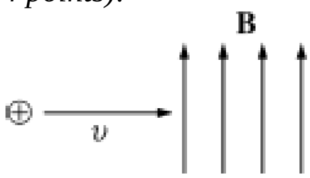
Midterm Physics II, Spring 2018, Feb 28

Name:

Show and explain your answer! ***Show and explain your answer!*** *Show and explain your answer!*
Useful constants: $k_e = 8.99 * 10^9$ $N * m^2/C^2$ $\quad \varepsilon_0 = 8.85 * 10^{-12}$ $C^2/N * m^2$ $\quad e = 1.6 * 10^{-19}$ C

1. *Question 1 (4 points):*

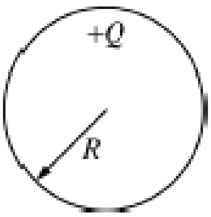


A proton moving to the right at constant speed v enters a region containing uniform magnetic and electric fields and continues to move in a straight line. The magnetic field $\mathbf{B}$ is directed toward the top of the page, as shown above. The direction of the electric field must be

(A) into the page
(B) out of the page
(C) to the left
(D) toward the top of the page
(E) toward the bottom of the page

Answer A

2. *Question 2 (4 points):*



The solid conducting sphere of radius R shown above has a charge $+Q$ distributed uniformly on its surface. The potential at the center of the solid sphere is

(A) $+\dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{R}$

(B) $-\dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{R}$

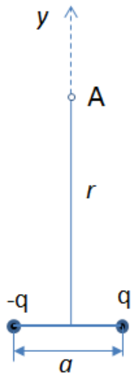
(C) $-\dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{R^2}$

(D) zero

(E) undefined

Answer A

3. (12 points) An electric dipole (two charges q and $-q$ separated by the distance a) is located perpendicular to the y axis (Figure). The magnitude of its electric dipole moment is defined as p=a*q. At a middle point A along the axis y calculate the a) exact electric field E(r) and potential V(r) b) Find the approximate asymptotic expression for the field E(r) for r located far from the dipole (r >>a) c) Find the energy of the dipole placed in an electric field E_0 which is perpendicular to y axis and d) parallel to y axis.



See Examples 23.5 and 25.4, and the Section 26.6

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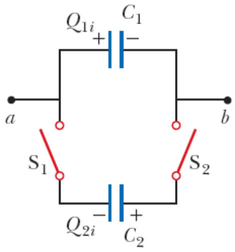
4. *(10 points)* Two capacitors C1 and C2 (where C1 > C2) are charged to the same initial potential difference ΔV_i. The charged capacitors are removed from the battery, and their plates are connected with opposite polarity as in Figure. The switches S1 and S2 are then closed (A) Find the final potential difference ΔV_f between a and b after the switches are closed. (B) Find the total energy stored in the capacitors before and after the switches are closed and determine the ratio of the final energy to the initial energy.



See Example 26.4

5. (10 points) A singly charged ion of mass m_1 is accelerated from rest by a potential difference ΔV. It is then deflected by a uniform magnetic field (perpendicular to the ion's velocity) into a semicircle of radius R_1. Now a doubly charged ion of mass m_2 is accelerated through the same potential difference and deflected by the same magnetic field into a semicircle of radius $R_2=2*R_1$. What is the ratio of the masses of the ions?

$$\frac{1}{2}mv^2 = q(\Delta V) \quad \text{so} \quad v=\sqrt{\frac{2q(\Delta V)}{m}}$$

$$r=\frac{mv}{qB} \quad \text{so} \quad r=\frac{m\sqrt{2q(\Delta V)/m}}{qB}$$

$$r^2=\frac{m}{q}\cdot\frac{2(\Delta V)}{B^2} \quad \text{and} \quad (r')^2=\frac{m'}{q'}\cdot\frac{2(\Delta V)}{B^2}$$

$$m=\frac{qB^2r^2}{2(\Delta V)} \quad \text{and} \quad (m')=\frac{(q')B^2(r')^2}{2(\Delta V)} \quad \text{so} \quad \frac{m'}{m}=\frac{q'}{q}\cdot\frac{(r')^2}{r^2}=\left(\frac{2e}{e}\right)\left(\frac{2R}{R}\right)^2=\boxed{8}$$

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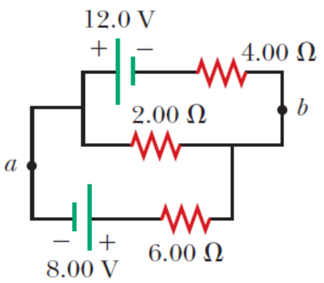
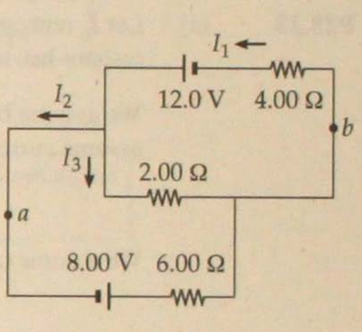
6. *(10 points)* For the circuit shown in Figure, calculate (a) the current in the 2.00 Ω resistor and (b) the potential difference between points *a* and *b*.



We name the currents I_1, I_2, and I_3 as shown.



ANS FIG. P28.22

(a) $I_1 = I_2 + I_3$

Counterclockwise around the top loop,

$$12.0\text{ V} - (2.00\ \Omega)I_3 - (4.00\ \Omega)I_1 = 0$$

Traversing the bottom loop,

$$8.00\text{ V} - (6.00\ \Omega)I_2 + (2.00\ \Omega)I_3 = 0$$

$$I_1 = 3.00 - \frac{1}{2}I_3,\ I_2 = \frac{4}{3} + \frac{1}{3}I_3, \quad \text{and} \quad \boxed{I_3 = 909\text{ mA}}$$

(b) $V_a - (0.909\text{ A})(2.00\ \Omega) = V_b$

$V_b - V_a = \boxed{-1.82\text{ V}}$

7. *Bonus (8 points)* A solid, insulating sphere of radius **R1** has a uniform volume charge density **ρ**. Inside the solid sphere a hollow, empty sphere of smaller radius **R2** is made. Center of the hollow sphere is at the distance **r** from the center of the solid sphere. Find the electric field inside the hollow sphere.

(I will explain it at the class)