Exam Total

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Physics 2135 Exam 2

Oct. 17, 2017

Name: Key

Rec. Sect: ____________

Five multiple choice questions, 8 points each. Choose the **best or most nearly correct** answer. For questions 6-9, solutions must begin with a correct OSE. You must show work to receive full credit for your answers. **Calculators are NOT allowed.**

(8) D 1. A parallel plate capacitor has capacitance C_0. The distance between the plates is halved and a dielectric slab with dielectric constant $K = 2$ is inserted so that it completely fills the space between the plates. The new value of the capacitance is:

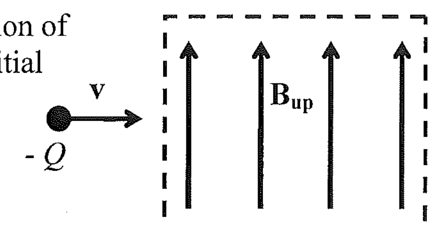
A. $2C_0$ B. $C_0/2$
C. C_0 D. $4C_0$

(8) C 2. A cylindrical copper conductor is to transport current parallel to the axis of the cylinder. Which cylinder will have the lowest resistance?

A. Short, small diameter, and hot B. Long, large diameter, and cold
C. Short, large diameter, and cold D. Long, small diameter, and hot

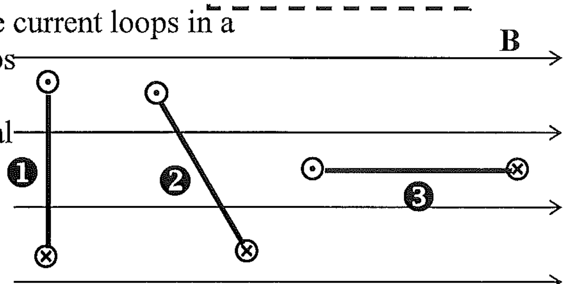
(8) C 3. A negatively charged particle enters a region of constant magnetic field as shown. The initial defection of the particle is

A. up B. down
C. into the page D. out of the page



(8) C 4. The diagram shows a side view of three current loops in a uniform magnetic field. All three loops are identical and each carries the same current. For which loop is the potential energy zero?

A. ❶ B. ❷
C. ❸ D. None of these



(8) Any 5. In 1908, a giant explosion occurred at Tanguska (Siberia) that was estimated at between 10-15 megatons and felled approximately 6 million trees in an area over 2000 square kilometers. Some believe Nikola Tesla's "Death Ray" was responsible for the explosion. Most likely

A. they are correct-never anger a physicist
B. they are nutcases, it was obviously the result of a meteor or comet
C. nope, nope, just UFOs having some fun
D. it was really a miniature black hole that passed through the earth

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6. Wire A has length L and wire B has length $2L$. Both wires have circular cross-sections. At room temperature (20° C) both wires have the same resistance. Wire A is made from material that has a resistivity that is one-half that of the material used to make wire B.

(20) a) Find the ratio of the radii of the two wires r_B/r_A.

$$R_A = R_B$$

$$\rho_A \frac{L_A}{A_A} = \rho_B \frac{L_B}{A_B}; \quad \rho_A = \frac{1}{2}\rho_B; \quad L_A = L; \quad L_B = 2L$$

$$\frac{1}{2}\rho_B \frac{L}{\pi r_A^2} = \rho_B \frac{2L}{\pi r_B^2}$$

$$\left(\frac{r_B}{r_A}\right)^2 = 4 \Rightarrow \boxed{\frac{r_B}{r_A} = 2}$$

(20) b) Both wires are now heated to 520° C. What is the ratio of the resistances of the two wires R_B/R_A at this elevated temperature? The temperature coefficient of the material for wire A is 2 $(° C)^{-1}$, and for the material in wire B it is 5 $(° C)^{-1}$. You may assume that the wires do not expand upon heating.

$$R = \rho \frac{L}{A} \Rightarrow \rho = \frac{RA}{L}$$

$$\frac{R(T)A}{L} = \frac{R_0 A}{L}(1 + \alpha(T - T_0))$$

$$R(T) = R_0(1 + \alpha(T - T_0))$$

$$R_A(T) = R_A(20)(1 + \alpha_A(T - T_0))$$

$$R_A(T) = R_A(20)[1 + 2(520 - 20)] = 1001 R_A(20)$$

$$R_B(T) = R_B(20)[1 + \alpha_B(T - T_0)]$$

$$R_B(T) = R_B(20)[1 + 5(520 - 20)] = 2501 R_B(20); \quad R_A(20) = R_B(20)$$

So $\frac{R_A(T)}{R_B(T)} = \frac{1001}{2501}$ or $\boxed{\frac{R_B(T)}{R_A(T)} = \frac{2501}{1001} \approx 2.5}$

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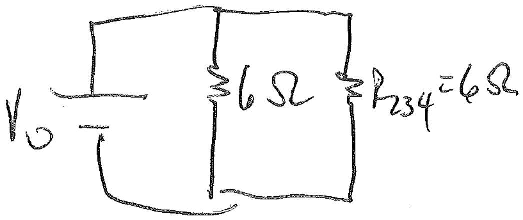
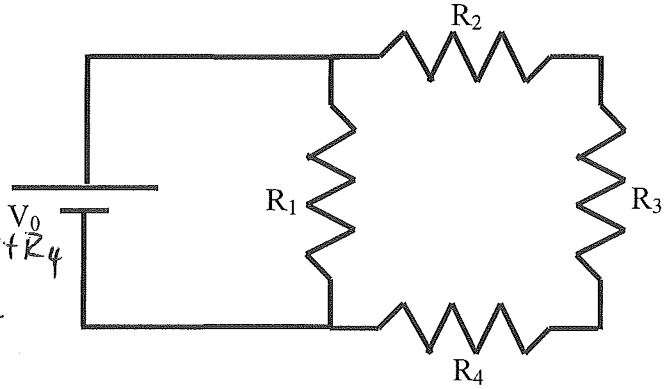
7. For the resistor circuit shown $R_1 = 6.0\ \Omega$, $R_2 = 1.0\ \Omega$, $R_3 = 2.0\ \Omega$, and $R_4 = 3.0\ \Omega$.

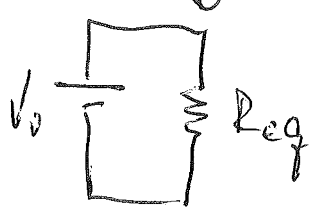
(20) a) Find the equivalent resistance.





$R_{234} = R_2 + R_3 + R_4$

$R_{234} = 6\ \Omega$



$$\frac{1}{R_{eq}} = \frac{1}{6} + \frac{1}{6} = \frac{1}{3}$$

$$\boxed{R_{eq} = 3\ \Omega}$$

(20) b) The power supply provides a potential difference $V_0 = 18$ V. Determine the power dissipated by resistor R_4.

$$V_0 = I_{eq} R_{eq} \Rightarrow I_{eq} = \frac{18}{3} = 6A$$

$$V_{234} = V_0 = 18V \Rightarrow I_{234} = \frac{18}{6} = 3A$$

$$P_4 = I_4^2 R_4 \ ; \ I_4 = I_{234} = 3A$$

$$\boxed{P_4 = (3)^2 (3) = 27W}$$

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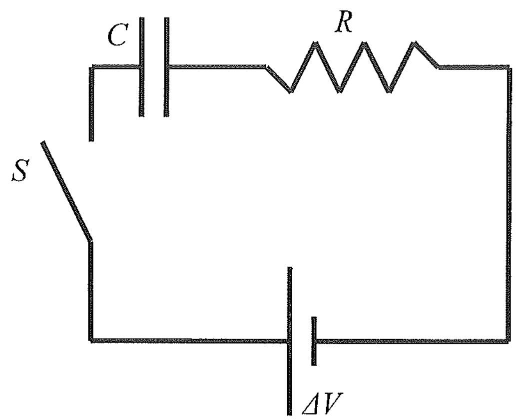
8. For the circuit shown $C = 6\ \mu F$ and $\Delta V = 25$ V. Initially the capacitor is uncharged. The switch S is then closed and the capacitor begins to charge.

(10) a) Determine the charge on the capacitor a very long time ($t \to \infty$) after the switch is closed.



As $t \to \infty$, $V_c \to \Delta V$

$$C = \frac{Q}{V_c} \Rightarrow Q = CV_c$$

$$Q(\infty) = C\Delta V = (6\mu F)(25V)$$

$$\boxed{Q(\infty) = 150\mu C}$$

(30) b) After the switch has been closed for time T the voltage across the capacitor is found to be 1/5 of its final value. Find R? You should express your answer in terms of system parameters (do not attempt a numerical solution).

$$Q(t) = Q_f(1 - e^{-t/\tau})$$

$$Q(t) = CV(t)$$

$$\cancel{C}V(t) = \cancel{C}V_f(1 - e^{-T/\tau})$$

$$V(t) = V_f(1 - e^{-T/\tau})$$

$$\frac{\cancel{V_f}}{5} = \cancel{V_f}(1 - e^{-T/\tau})$$

$$\frac{1}{5} - 1 = -e^{-T/\tau}$$

$$\frac{4}{5} = +e^{-T/\tau}$$

$$\ln\left(\frac{4}{5}\right) = \frac{-T}{\tau} \Rightarrow \tau = RC = \frac{-T}{\ln\left(\frac{4}{5}\right)}$$

$$R = \frac{-T}{C \ln\left(\frac{4}{5}\right)}$$

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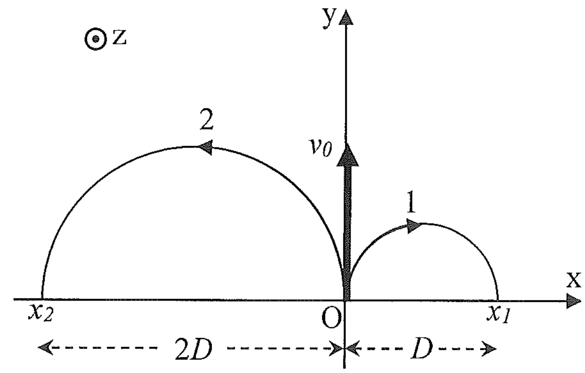
9. Particle 1 having known initial velocity $\vec{v}_1 = v_0\hat{j}$, positive charge $Q_1 = +Q$, and mass $M_1 = M$ passes through the origin O and enters a region of uniform magnetic field of unknown magnitude which is known to be either parallel (out of page) or anti-parallel (into the page) to the z-axis. It strikes the x-axis at $x_1 = D$. A second particle of unknown mass having a charge of unknown sign but known magnitude Q passes through the origin with the same initial velocity and strikes the x-axis at $x_2 = -2D$.



(5) a) What is the direction of $\vec{B}$ ($+\hat{k}$ or $-\hat{k}$)?

$\vec{F}_B$ along $+\hat{i}$ initially so $\vec{v} \times \vec{B}$ along $+\hat{i}$ ($Q_1 > 0$). This occurs when $\boxed{\vec{B} = +B\hat{k}}$

(5) b) What is the sign of Q_2 (+ or -)?

$\vec{F}_{B_2}$ in opposite direction as $\vec{F}_{B_1}$ $\Rightarrow$ $\boxed{Q_2 < 0}$

(15) c) Find the magnitude B of the magnetic field.

Particle 1: $Q_1 V_1 B = \dfrac{M V_1^2}{(D/2)}$

$$\boxed{B = \frac{2MV_1}{Q_1 D} = \frac{2Mv_0}{QD}}$$

(15) d) Find the mass, M_2, of particle 2.

$|Q_2| v_2 B = \dfrac{M_2 v_2^2}{D}$; $v_2 = v_0$

$$M_2 = \frac{|Q_2| B D}{v_2} = \frac{|Q|\left(\frac{2Mv_0}{QD}\right)D}{v_0}$$

$$\boxed{M_2 = 2M}$$

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