Physics 116 - Exam I

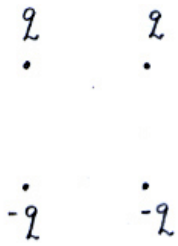
4 February 2004

Please do not turn the page until you are told to. When you do so, make sure that you have all three problems on your copy of the test.

In order to get credit on a problem, you must show your work. If you only write down an answer without the work leading up to it, you will get no credit for it, even if it is the right answer.

(1) Consider four charges placed at the corners of a square, as indicated in the figure. The side of the square is 3.0 cm, and charge $q = 2\ \mu$C.

(a) (7 points) What is the magnitude of the total electrostatic force exerted on the charge in the upper left corner by the other three charges?



(b) (3 points) Indicate the direction of the total force from part (a). You don't need to give an angle, but draw an arrow in the direction of the force, or write in words if it is up, left, down and right, etc.

(c) (5 points) What is the total electric field produced by the four charges at the center of the square? Please give both the magnitude and direction.

(d) (5 points) What is the total electric potential at the center of the square, where the reference potential is chosen to be zero at infinity?

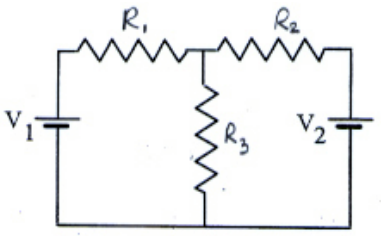
(2) A conducting sphere of radius 0.5 m carries a net charge of $-6\ \mu$C. The sphere is located at the center of a conducting spherical shell of radius 0.8 m that carries a net charge of $+2\ \mu$C.

(a) (6 points) Please determine the excess charge on the outer surface of the spherical shell.

(b) (7 points) What is the electric field (magnitude and direction) 0.3 m from the common center of the sphere and shell?

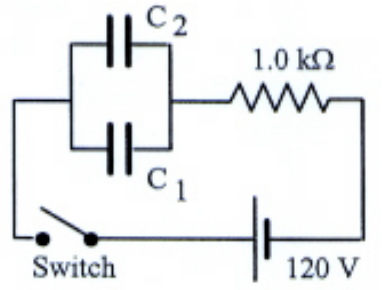
(c) (7 points) What is the electric field (magnitude and direction) 0.9 m from the common center of the sphere and shell?

(3) (a) (10 points) Three resistors and two batteries are connected as shown in the circuit diagram. The three resistances and the two voltages are known. Please clearly label the currents in the circuit and indicate their direction (chosen by you). Then write enough independent equations to solve for the currents (You don't need to solve for them.).



(3) (b) An RC circuit consists of a resistor with resistance 1.0 $k\Omega$, a 120 V battery, and two capacitors, C_1 and C_2, with capacitances of 20.0 μF and 60.0 μF, respectively. Initially, the capacitors are uncharged, and the switch is closed at $t = 0$ s.

(5 points) What is the current through the resistor *a long time* after the switch is closed?



(5 points) (c) What is the time constant of the circuit?

$$F = k\frac{|q_1||q_2|}{r^2}$$

$$k = \frac{1}{4\pi\epsilon_0}$$

$$\vec{E} = \frac{\vec{F}}{q_0}$$

$$E = k\frac{|q|}{r^2}$$

$$E = \frac{\sigma}{\epsilon_0}$$

$$\Phi_E = \Sigma(E\cos\theta)\Delta A$$

$$\Phi_E = \frac{Q_{encl}}{\epsilon_0}$$

$$V = \frac{EPE}{q_0}$$

$$V_B - V_A = \frac{-W_{AB}}{q_0}$$

$$V = \frac{kq}{r}$$

$$E = -\frac{\Delta V}{\Delta s}$$

$$EPE = k\frac{q_1 q_2}{r}$$

$$q = CV$$

$$\kappa = \frac{E_0}{E}$$

$$C = \frac{\kappa\epsilon_0 A}{d}$$

$$Energy = \frac{1}{2}CV^2$$

$$I = \frac{\Delta q}{\Delta t}$$

$$V = IR$$

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

$$\rho = \rho_0[1 + \alpha(T - T_0)]$$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$V = V_0\sin\omega t$$

$$I = I_0\sin\omega t$$

$$\omega = 2\pi f$$

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$P_{avg} = I_{rms}V_{rms}$$

$$R_{eq} = R_1 + R_2 + ...$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + ...$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + ...$$

$$C_{eq} = C_1 + C_2 + ...$$

$$q = q_0(1 - e^{-t/(RC)})$$

$$q = q_0 e^{-t/(RC)}$$

$$\tau = RC$$

.....constants.....

$$g = 9.8\ m/s^2$$

$$k \approx 9 \times 10^9 N \cdot m^2/C^2$$

$$\epsilon_0 = 8.854 \times 10^{-12} C^2/N \cdot m^2$$

$$e = 1.60 \times 10^{-19} C$$