

Name: _____ KEY _____

Phys.116 Exam I
7 February 2007

Please do not turn the page until you are told to do so. Make sure that you have all six 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) (10 points) An electron is moving in the positive x-direction with a speed of 6.00×10^6 m/s. It enters a region with an electric field which is directed in the positive y-direction. If the electric field is 300 N/C, what is the acceleration (magnitude and direction) of the electron in the field? ($m_e = 9.11 \times 10^{-31}$ kg)

$$\sum F = ma$$

$$F = qE$$

$$qE = ma$$

$$a = \frac{qE}{m} = \frac{(-1.60 \times 10^{-19} \text{ C})(300 \text{ N/C})}{9.11 \times 10^{-31} \text{ kg}} = \boxed{-5.3 \times 10^{13} \text{ m/s}^2}$$

The direction of the acceleration is in the opposite direction of that of the electric field, so it's in the negative y-direction.

2) (10 points) Two identical conducting spheres carry charges of $+5.0 \mu\text{C}$ and $-1.0 \mu\text{C}$, respectively. The centers of the spheres are initially separated by a distance L . The two spheres are brought together so that they are in contact. The spheres are then returned to their original separation L . What is the ratio of the magnitude of the electric force on either sphere *after* the spheres are touched to that *before* they were touched?

$$F_{\text{before}} = k \frac{|Q_{1\text{before}}| |Q_{2\text{before}}|}{L^2} = k \frac{(5\mu\text{C})(1\mu\text{C})}{L^2}$$

When the spheres touch, the charges redistribute themselves, so when the spheres are separated again, each

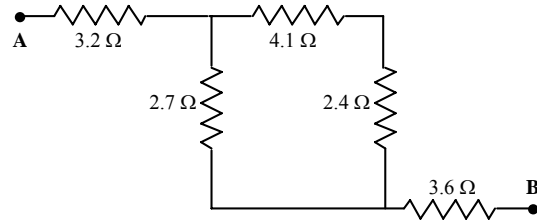
one carries a charge of $\frac{5\mu\text{C} + (-1\mu\text{C})}{2} = 2\mu\text{C}$

$$F_{\text{after}} = k \frac{|Q_{1\text{after}}| |Q_{2\text{after}}|}{L^2} = k \frac{(2\mu\text{C})(2\mu\text{C})}{L^2}$$

$$\boxed{\frac{F_{\text{after}}}{F_{\text{before}}} = \frac{4}{5}}$$

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Total/60	

3) Five resistors are connected as shown in the diagram. The potential difference between points A and B is 15 V.



a) (5 points) What is the equivalent resistance between the points A and B?

The 4.1 Ω and 2.4 Ω resistors are connected in series. Their equivalent resistance is $4.1\ \Omega + 2.4\ \Omega = 6.5\ \Omega$.

The 6.5 Ω and 2.7 Ω resistors are connected in parallel. Their equivalent resistance is

$$\left(\frac{1}{6.5\ \Omega} + \frac{1}{2.7\ \Omega} \right)^{-1} = 1.9\ \Omega.$$

The 3.2 Ω, 1.9 Ω, and 3.6 Ω resistors are connected in series. Their equivalent resistance is $3.2\ \Omega + 1.9\ \Omega + 3.6\ \Omega = \boxed{8.7\ \Omega}$.

b) (5 points) What is the current in the 3.6-Ω resistor?

$$I_{3.6} = \frac{V_{tot}}{R_{eq}} = \frac{15\ \text{V}}{8.7\ \Omega} = \boxed{1.7\ \text{A}}$$

c) (5 points) What is the current in the 2.7-Ω resistor?

The voltage across the 2.7 Ω resistor is $V_{tot} - V_{3.6} - V_{3.2} = 15\ \text{V} - (1.7\ \text{A})(3.6\ \Omega + 3.2\ \Omega) = 3.4\ \text{V}$

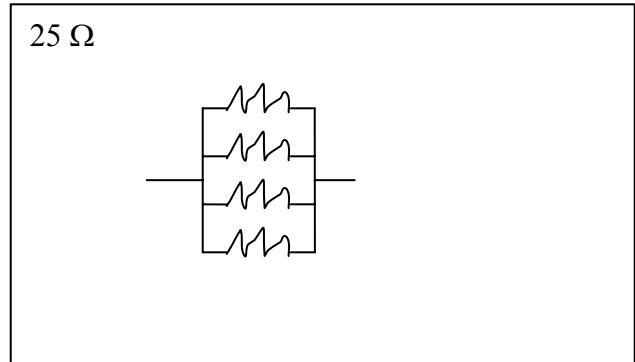
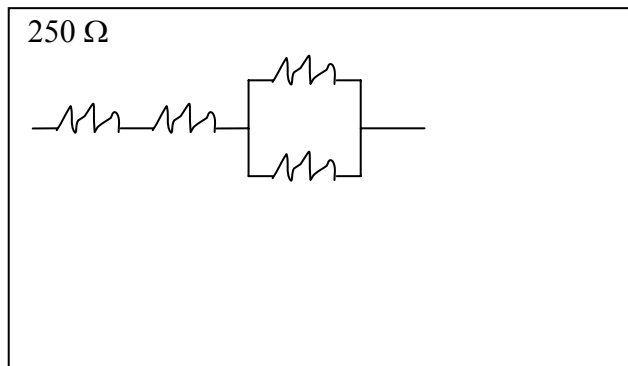
Then the current through it is $I_{2.7} = \frac{V_{2.7}}{R_{2.7}} = \frac{3.4\ \text{V}}{2.7\ \Omega} = \boxed{1.3\ \text{A}}$

d) (5 points) What amount of energy is dissipated in the 2.7-Ω resistor in 9.0 seconds?

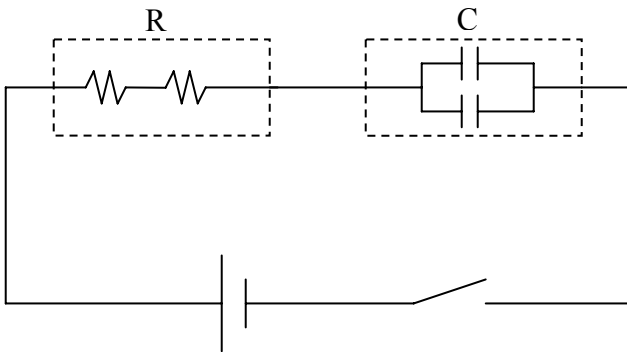
Energy=(Power)(time)

$$\text{Energy} = I_{2.7} V_{2.7} t = (1.3\ \text{A})(3.4\ \text{V})(9.0\ \text{s}) = \boxed{40\ \text{J}}$$

4) (10 points) You are given two black boxes, each of which contains *four* $100\ \Omega$ resistors. In each box, the four resistors are connected in a particular circuit. With an ohmmeter you measure the total resistance of each circuit, and obtain the values for the total resistance of each circuit. Based on those measurements, sketch the wiring diagrams for each box.

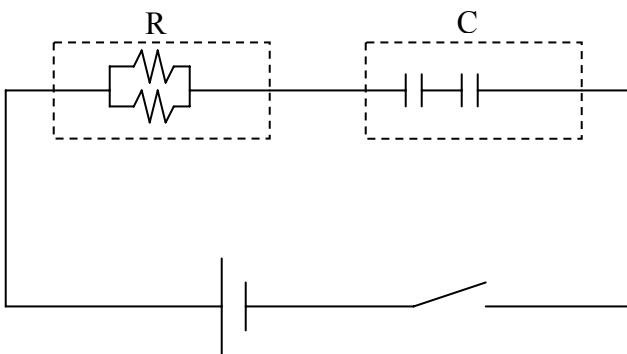


5) (5 points) You are provided with two identical capacitors ($C_1 = C_2 = 40\ \mu\text{F}$) and two identical resistors ($R_1 = R_2 = 2200\ \Omega$). Complete the circuit that includes all four components and has the *longest* time constant. Calculate the time constant.



$$\tau = R_{eq} C_{eq} = (R + R)(C + C) = (4400\ \Omega)(80 \times 10^{-6}\ \text{F}) = \boxed{0.352\ \text{s}}$$

6) (5 points) Complete the circuit that includes all four components from problem (5) and has the *shortest* time constant. Calculate the time constant.



$$\tau = R_{eq} C_{eq} = \left(\frac{1}{R} + \frac{1}{R}\right)^{-1} \left(\frac{1}{C} + \frac{1}{C}\right)^{-1} = (1100\ \Omega)(20 \times 10^{-6}\ \text{F}) = \boxed{0.022\ \text{s}}$$