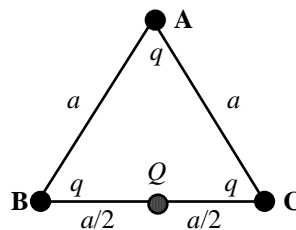


Name: _____ KEY _____

Phys.116 Exam I
8 February 2006

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. The figure shows an equilateral triangle **ABC**. A positive point charge $+q$ is located at each of the three vertices **A**, **B**, and **C**. Each side of the triangle is of length a .

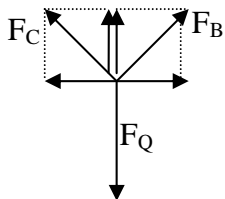


A point charge Q (that may be positive or negative) is placed at the mid-point between **B** and **C**.

- a. (6 points) Is it possible to choose the value of Q (*that is non-zero*) such that the force on Q is zero? Explain why or why not.

No. The forces from **B** & **C** on Q will cancel each other out (same magnitude and opposite directions), but the force from **A** on Q will still be there.

- b. (7 points) Determine an expression for the magnitude and sign of Q so that the net force on the charge at **A** is zero newtons. Write your answer in terms of q , k , and a .



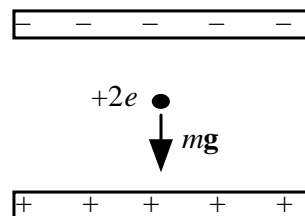
Q has to be negative, so that the repelling forces from **B** and **C** would be cancelled by an attractive force from Q .

$$F_Q = F_{C_y} + F_{B_y} = 2F_C \cos 30^\circ;$$

$$k \frac{Qq}{\left(\frac{a\sqrt{3}}{2}\right)^2} = 2k \frac{qq}{a^2} \left(\frac{\sqrt{3}}{2}\right)$$

$$\Rightarrow Q = -\frac{3\sqrt{3}}{4} q$$

2. (7 points) A helium nucleus is located between the plates of a parallel-plate capacitor as shown. The nucleus has a charge of $+2e$ and a mass of 6.6×10^{-27} kg. What is the magnitude of the electric field such that the electric force exactly balances the weight of the helium nucleus so that it remains stationary?



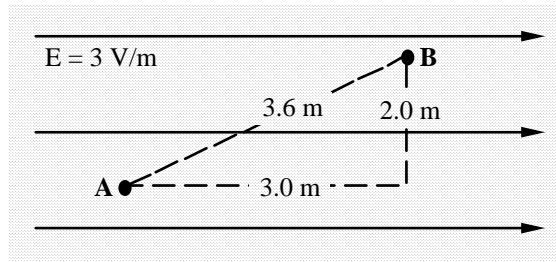
$$F_{el} = mg$$

$$qE = mg$$

$$E = \frac{mg}{2e} = 2.0 \times 10^{-7} \text{ N/C}$$

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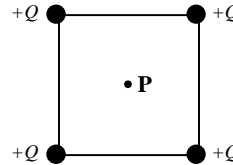
3. (5 points) A $+1.0 \mu\text{C}$ point charge is moved from point **A** to **B** in the uniform electric field as shown. By how much does the electric potential of the point charge change during the move? Does it increase or decrease?



$$E = -\frac{\Delta V}{\Delta s}; \Delta V = -E\Delta s = -(3\text{V/m})(3.0\text{m}) = -9\text{V}$$

V decreases by 9V .

4. Four point charges are individually brought from infinity and placed at the corners of a square as shown in the figure. Each charge has the identical value $+Q$. The length of the diagonal of the square is $2a$. Write your answers to the following questions in terms of Q , k , and a .



- a. (5 points) The *first two* charges are brought from infinity and placed at adjacent corners. What is the **electric potential energy** of these two charges?

$$EPE = k \frac{Q_1 Q_2}{r} = k \frac{QQ}{a\sqrt{2}} = k \frac{Q^2}{a\sqrt{2}}$$

- b. (5 points) What is the magnitude of the **electric field at P**, the center of the square after all four charges are in place?

The E-fields of the four equal charges cancel out in the center of the square.

- c. (5 points) What is the **electric potential at P**, the center of the square when all four charges are in place?

The potentials due to the 4 charges add algebraically.

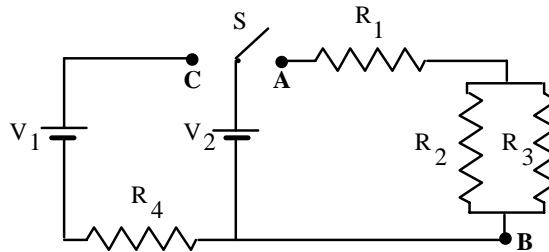
$$V = 4k \frac{Q}{a}$$

5. The figure shows a circuit. The switch S can be closed on either point A or C , but not both at the same time. Use the following quantities:

$$V_1 = V_2 = 12 \text{ V}$$

$$R_1 = R_4 = 1.0 \Omega$$

$$R_2 = R_3 = 2.0 \Omega$$



a. (7 points) What is the equivalent resistance between the points A and B ?

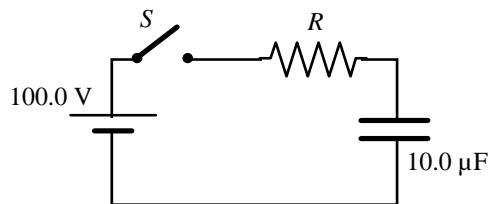
$$R_{23} = \frac{R_2 R_3}{R_2 + R_3} = 1 \Omega$$

$$R_{123} = R_1 + R_{23} = \boxed{2 \Omega}$$

b. (6 points) Determine the current through R_4 when the switch S is closed on C .

The current through R_4 is zero. The two power supplies supply the same amount of current in opposite directions, thereby canceling out the current.

6. (7 points) The figure shows a simple RC circuit consisting of a 100.0-V battery in series with a 10.0- μF capacitor and a resistor. Initially, the switch S is open and the capacitor is uncharged. Two seconds after the switch is closed, the voltage across the capacitor is 37 V. Determine the numerical value of the resistance R .



$$V = V_0(1 - e^{-t/RC})$$

$$37 \text{ V} = 100 \text{ V}(1 - e^{-2/RC})$$

$$.37 - 1 = -e^{-2/RC}$$

$$\ln(0.63) = \frac{-2}{R(10.0 \times 10^{-6} \text{ F})}$$

$$R = 4.3 \times 10^5 \Omega$$