

# Physics 112, Spring 2016 Exam 1 51 pts

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## RULES

You may use an equation sheet with whatever you want on both sides, you may not use a tablet or a smartphone or a laptop as a calculator. Do not forget to include direction in all answers.

### **Conceptual**

1:) You are given two protons and two electrons. You are tasked with placing these charges at the four corners of a square in a manner that would cause an electron, initially set down in the middle of the square, to move A - left B - Right C - up D - down. Draw these four configurations (4 pts)

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2: A uniform electric field exists between two plates resulting in a potential difference  $\Delta V$  between them. (see figure on the board) Answer the following questions and supply a drawing to support your reasoning.

A) An electron is shot horizontally, into the space between the plates from the right. Sketch its subsequent trajectory. Do the same for a proton. CLEARLY label which is a proton and which is an electron. Draw the direction the electric field point between these plates. (2 pts)

B) A hole is carved out from the bottom plate with a hole in the same location on the top plate. Describe how you would go about quantitatively determining if a proton shot through from the bottom would make it out if all you are given the proton's initial kinetic energy and the potential difference between the plates. Be specific, this question has a one line answer. More specifically, write down an equation/expression/inequality that determines if the proton makes it or not. (3 pts)

C) Explain how, if given the electric field in between the plates, you could determine what plate spacing you would need to just stop the proton at the top. I want an algebraic equation/expression/inequality for  $\Delta x$  in terms of the electric field, initial kinetic energy, etc. (2 pts)

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3:) Explain the distinction between electric field and the electric force. Two sentences at most. (2 pts)

### **Problems**

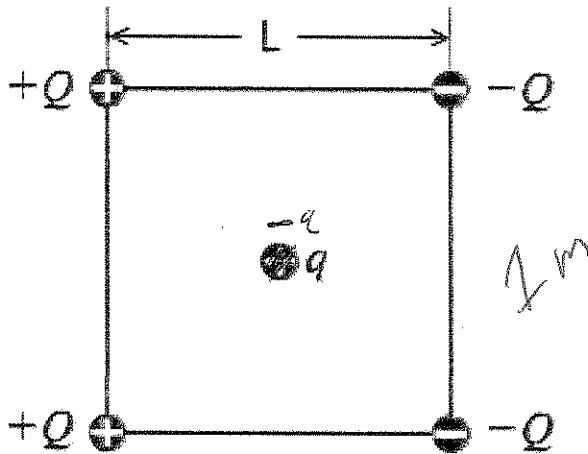
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1:) Look at the figure below (it is a square).

A) Calculate the magnitude and direction of the electric field at the point q is. Do this algebraically first with no numbers. THEN give me the magnitude and direction of the electric field using numbers. Draw out your geometry and show how you came to this result. (8 pts)

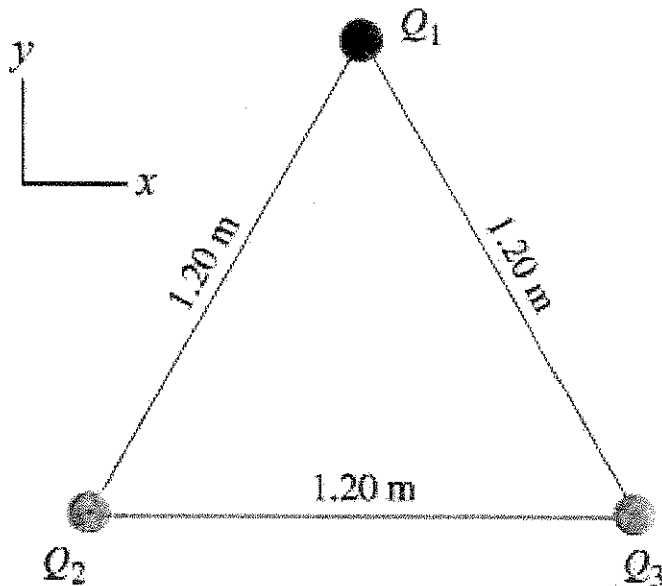
B) Assume  $|q| = 1.6 \times 10^{-19}$  Coulombs. Calculate the force on q if q were an electron and if q were a proton. I want direction and magnitude. (3 pts)

C) Calculate the acceleration (magnitude and direction) if  $q$  was an electron. I want numbers here. (3 pts)



Five point charges.

2:) 2 protons form the bottom corners of an equilateral triangle with an alpha particle ( $q = 2|e|$  and  $m = 4m_p$ ) at it's top.



A) Initially, all particles are held down. What is the potential energy, in joules, of this system? First give me a purely algebraic expression and THEN calculate the energy. (6 pts)

B) The alpha particle is now let go while the protons are held down. What kinetic energy does

the alpha particle gain? (5 pts)

C) What is its final velocity? (2 pts)

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3:) A Vacuum cleaner with a 2 meter cord is plugged into a 110 volt electrical socket when it is 20 degrees celsius.

A) The current the vacuum cleaner draws is 10 amperes. Determine the resistance in the wire and with that the cross sectional area of the wire in the cord. Assume the wire is made of copper. (4 pts)

B) What power does the vacuum cleaner draw? (2 pts)

C) You now go outside on a hot day when it is 40 degrees celsius. Determine the new resistance in the wire and the new current the vacuum cleaner draws. (3 pts)

D) If power is 10 cents per kilowatt hour, how much more, per kilowatt hour, is the vacuum cleaner going to cost you when using it outside on a hot day. (2 pts)

### Constants

$$k = 9 \times 10^9 \frac{Nm^2}{C^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$$

$$m_e = 9.1 \times 10^{-31} kg$$

$$m_p = 1.67 \times 10^{-27} kg$$

$$|e| = 1.6 \times 10^{-19} C$$

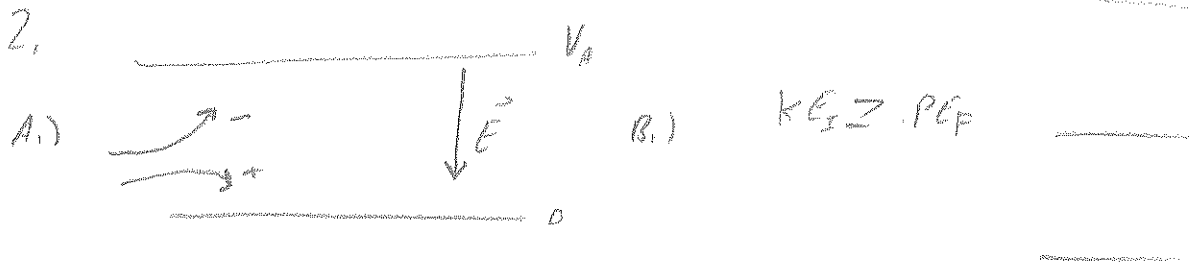
$$\rho_c = 1.7 \times 10^{-8} \Omega m$$

$$\alpha_c = 3.9 \times 10^{-3} C^{-1}$$

$$density_{copper} = 8960 kgm^{-3}$$

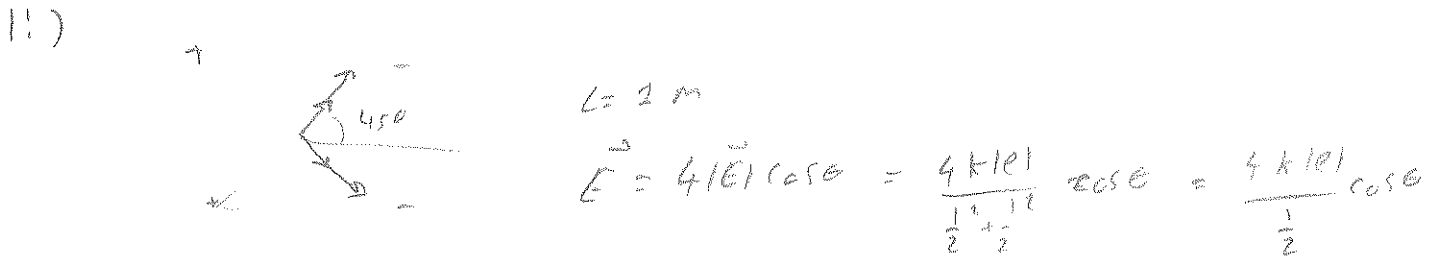
$$mass_{copper\ atom} = 58 * m_p$$





C.)  $\frac{1}{2}mv^2 = eE \Delta x$

3.)  $\vec{E}$  due to outside charges  $q\vec{E}$  force on  $q$



A.)  $\vec{E} = \frac{8|e|}{\sqrt{2}} = 3.15 \cdot 10^{-9} \frac{\text{N}}{\text{C}}$

B.)  $\vec{F} = q\vec{E} = \pm 1.3 \cdot 10^{-27} \text{ N}$   $\rightarrow$  proton - electron

C.)  $\frac{q\vec{E}}{m} = \vec{a} = -1472.24 \frac{\text{m}}{\text{s}^2}$

$$2.) E_I = PE_{12} + PE_{13} + PE_{23} = \frac{2k1e1^2}{r_{12}} + \frac{2k1e1^2}{r_{13}} + \frac{k1e1^2}{r_{23}}$$

$$A.) E_I = \frac{5k1e1^2}{r} = 9,6 \cdot 10^{-28} \text{ J}$$

$$B.) PE_{12} + PE_{13} = KE_F \quad \frac{4k1e1^2}{r_{12}} = \frac{1}{2} m v^2 = 7,68 \cdot 10^{-28} \text{ J}$$

$$C.) \left[ \frac{2 (7,68 \cdot 10^{-28} \text{ J})}{m} \right]^{1/2} = v = 0,48 \frac{\text{m}}{\text{s}}$$

$$3.) A.) \Delta V = I R \quad R = \frac{\Delta V}{I} = 11 \Omega$$

$$R = \frac{\rho L}{A} \quad A = \frac{\rho L}{R} = 3,09 \cdot 10^{-9}$$

$$B.) P = I \Delta V = 1100 \text{ WATT}$$

$$C.) R = R_0 (1 + \alpha(T - T_0)) = 11,86 \Omega \quad I = \frac{\Delta V}{R} = 9,27 \text{ A}$$

$$D.) \frac{11,86}{11} = 1,08 \rightarrow 10,8 \text{ k} \\ \text{Kw mit Heizer}$$