

Physics 112, spring2015 Exam 1 70 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:) Look at the arrangements of particles on the board.

A) In which direction does the proton move? Sketch out, using vectors, the individual forces on the proton and the net force. (4 pts)

B) In which direction does the electron move? Sketch out, using vectors, the individual forces on the electron and the net force. (4 pts)

2:) A uniform electric field exists between two plates resulting in a potential difference ΔV 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. (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. (4pts)

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 for Δx in terms of the electric field, initial kinetic energy, etc. (4 pts)

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3:) Explain the distinction between electric potential and electric potential energy. (2 pts)

Problems

1:) Two protons are pinned down with one proton at $x = .1m$ and $y = 0m$ and the proton at $x = 0m$ and $y = 0m$.

A) Determine the electric field \vec{E} at $x = .05m$ and $y = 0.0866m$ I want the magnitude and direction of the field. (12 pts)

B) Determine the magnitude of the force on an electron at this point and its acceleration and direction of acceleration. (6 pts)

2:) A point charge of $q_s = 2\mu C$ is placed at the origin.

A) Using energy, determine the change in the potential energy of a proton as it moves (at rest initially) from $x = 10^{-2}m$ to $x = 10^6m$ In Joules. (6 pts)

B) what is the change of the kinetic energy of the proton? (3 pts)

C) What is it's final velocity? (3 pts)

3:) A 100km long copper wire with a cross sectional area of $8 \times 10^{-5}m^2$ is used to transmit power. The voltage at the power company is 500 kV and the line transmits a current of 1000 amperes. Assume 20 degrees C

A) What is the voltage at the end of the line if the temperature is 20 degrees celcius? Be careful, I want the final voltage not just Δv . (6 pts)

B) What is the power lost over the course of the line? (2 pts)

C) When the temperature rises to 40 degrees C what is the resistance? (4 pts)

D) How long does it take the an electron from a copper atom to reach the end of the line if it started at the beginning. Assume each copper atom contributes one electron. (8 pts)

Constants

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

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

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

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

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

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

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

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

$$mass\ copper\ atom = 58 * m_p$$

$$2.) \text{Var. } 0.2 \text{ m} \quad \frac{ka}{r_1} = 1.8 \cdot 10^6 \frac{\text{J}}{\text{C}}$$

$$|\Delta PE| = q |\Delta V| = |kE_F|$$

$$\Delta V \sim \text{just Var. } 0.1 \text{ m} \quad \text{So } \Delta PE_{\text{JUST}} = \frac{k(2m_e \cdot 1e)}{r}$$

$$|\Delta PE| = 2.88 \cdot 10^{-13} \text{ J} = \frac{1}{2} m_p v_p^2$$

$$v = 1.86 \cdot 10^7 \frac{\text{m}}{\text{s}}$$

$$3.) \text{ a.) } R = \frac{\rho L}{A} = 21.25 \Omega, \quad \Delta V_{IR} = \frac{500 \text{ kV} - IR}{21150 \text{ V}} = 47.8750$$

$$\text{b.) } P = I^2 R = 2.125 \cdot 10^7 \text{ W}$$

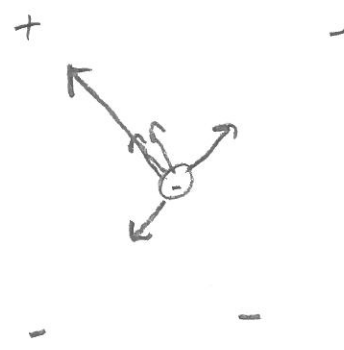
$$\text{c.) } R = R_0 (1 + \alpha \Delta T) = 21.33 \Omega \quad \Delta T = 20^\circ$$

$$\text{d.) } v_d = \frac{I}{nqA} \quad n = \frac{\text{density}}{\text{mass}} = \frac{9.25 \cdot 10^{28}}{1.6 \cdot 10^{-19} \cdot 1.8 \cdot 10^{-5}}$$

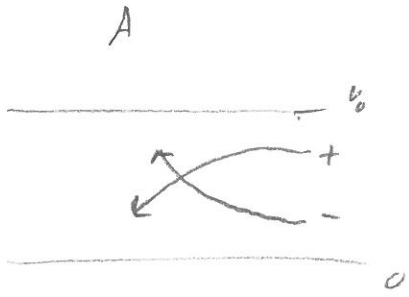
$$v_d = \frac{1000}{9.25 \cdot 10^{28} \cdot 1.6 \cdot 10^{-19} \cdot 1.8 \cdot 10^{-5}} = 8.4 \cdot 10^{-4} \frac{\text{m}}{\text{s}}$$

$$\Delta T = \frac{\Delta x}{v_d} = 1.19 \cdot 10^8 \text{ s}$$

1.) + +



2.)

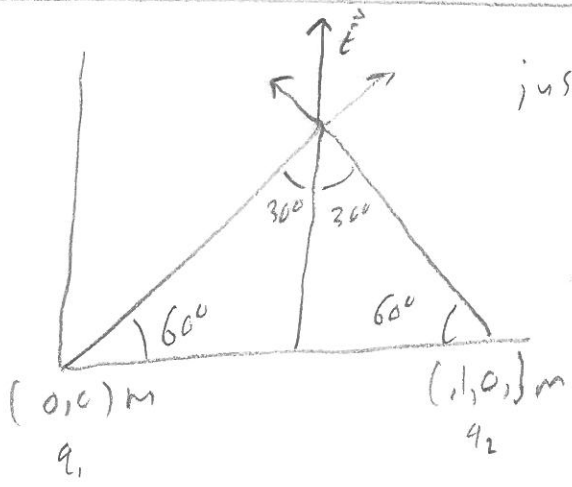


$$|kE_I| > |q\phi|$$

$$\frac{kE_I}{|q(E_I)|} = \Delta x$$

3.) One due to field, one energy of particle in field

1.



just $2 \cdot E_{y1}$ or $2 \cdot E_{y2}$

$$|E_I| = \frac{ke}{r^2} = 1.44 \cdot 10^{-7} \frac{N}{C}$$

$$E_{y1} = |E_I| \sin(60^\circ)$$

$$\vec{E} = (2 E_{y1}) \hat{y} = (2.49 \cdot 10^{-7} \frac{N}{C}) \hat{y}$$

$$|\vec{F}| = q |\vec{E}| = 3.99 \cdot 10^{-26} N$$

$$|\vec{a}| = \frac{|\vec{F}|}{m} = 43853 \frac{m}{s^2} \downarrow$$