Physics 10164 - Exam 1A

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (40 pts) A +6.5 μC charge is located at the origin. It is fixed in place and does not move during this problem. A 35 gram mass with a net charge of -3.3 μC is located at x = 26 cm.

The 35-gram mass starts at rest and moves 11 cm due to the electric force it feels. Assuming no other force is relevant in the problem, what is the final velocity of the 35-gram mass?

$$V_i = \frac{kq}{r_i} = \frac{(9\times10^9)(6.5\times10^{-6})}{0.26} = 225{,}000 \text{ Volts}$$

$$V_f = \frac{kq}{r_f} = \frac{(9\times10^9)(6.5\times10^{-6})}{0.15} = 390{,}000 \text{ Volts}$$

$-3.3\,\mu C$ moves toward origin since electric force from $+6.5\,\mu C$ charge is attractive

$$W_E = -\Delta U_E = -q\,\Delta V$$

q ← moving charge; ΔV ← potential that charge is moving through

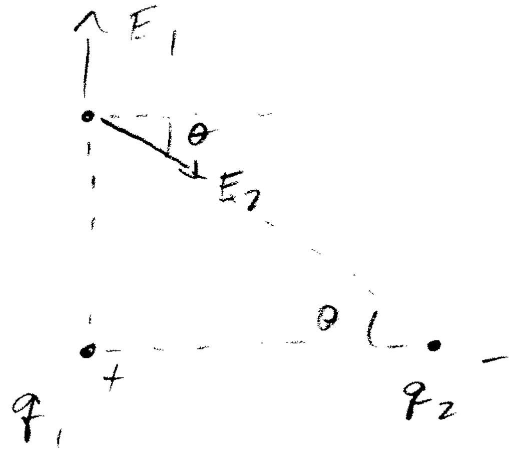
$$W_E = -(-3.3\times10^{-6})(390{,}000 - 225{,}000) = 0.5445 \text{ J}$$

$$\Sigma W_F = 0.5445 \text{ J} = \tfrac{1}{2}mv^2 - 0$$

$$0.5445 = \tfrac{1}{2}(.035)v^2$$

$$\boxed{v = 5.6 \text{ m/s}}$$

2. (30 pts) A +3.5 μC charge is located at the origin. A −4.2 μC charge is located at x = 68 cm. Both are fixed in place. What is the magnitude and direction of the electric field at y = 48 cm?



$\theta = \tan^{-1}\left(\frac{48}{68}\right) = 35.2^\circ$

$r_2 = \sqrt{.48^2 + .68^2} = 0.832\ m$

$|\vec{E}_1| = \frac{kq_1}{r_1^2} = \frac{(9\times10^9)(3.5\times10^{-6})}{0.48^2} = 137{,}000\ \frac{V}{m}$

$|\vec{E}_2| = \frac{kq_2}{r_2^2} = \frac{(9\times10^9)(4.2\times10^{-6})}{.832^2} = 54{,}600\ \frac{V}{m}$

$E_{1x} = 0$

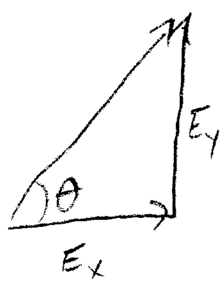
$E_{1y} = 137{,}000\ \frac{V}{m}$

$E_{2x} = 54600 \cos 35.2^\circ = 44600$

$E_{2y} = -54600 \sin 35.2^\circ = -31{,}500\ \frac{V}{m}$

$E_{TOT,x} = 44600$

$E_{TOT,y} = 105{,}500$



$E_{TOT} = \sqrt{44600^2 + 105500^2} = \boxed{110{,}000\ \frac{V}{m}}$

$\theta = \tan^{-1}\left(\frac{105500}{44600}\right) = \boxed{67^\circ \text{ above } +x}$

3. (30 pts) A wire has a resistivity of 3.0 x 10^{-8} Ohm-meters, a length of 1.5 km and a diameter of 5.0 mm.

a) What is the resistance of the wire?

b) A potential difference of 120 Volts is applied to the ends of the wire. How much power is dissipated by the wire?

c) Assuming energy costs 14 cents per kilowatt-hour. How much money (to the nearest cent) does it cost per day to maintain this wire.

$$R = \frac{\rho l}{A} \qquad l = 1500\ m$$

$$A = \frac{1}{4}\pi(.005)^2 = 1.96 \times 10^{-5}\ m^2$$

a) $$R = \frac{(3.0 \times 10^{-8})(1500)}{1.96 \times 10^{-5}} = \boxed{2.3\ \Omega}$$

b) $$P = \frac{\Delta V^2}{R} = \frac{120^2}{2.3} = \boxed{6300\ \text{Watts}}$$

c) $$t = 1\ \text{day} = 86400\ s$$

$$E = \left(6300\ \frac{J}{s}\right)(86400\ s)$$

$$= 5.41 \times 10^8\ J \cdot \frac{1\ kW \cdot hr}{3.6 \times 10^6\ J} = 150\ kW \cdot hr$$

$$\text{cost} = 150\ kW \cdot hr \cdot \frac{14\ \text{cents}}{kW \cdot hr} = \boxed{2103\ \text{cents}}$$