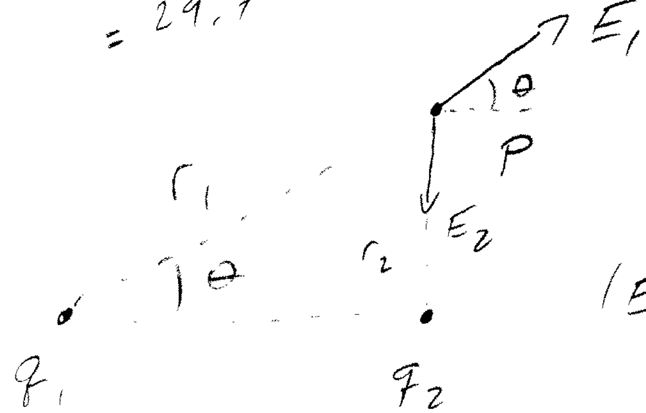
Physics 10164 - Exam 1A

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. (30 pts) A +3.5 μC charge is located at the origin. A -2.2 μC charge is located on the x-axis as x = 3.5 cm. Find the magnitude and direction of the electric field on a point P located at the coordinates (x,y) = (3.5 cm, 2.0 cm).

$$\theta = \tan^{-1}\left(\frac{2.0}{3.5}\right) = 29.7^\circ$$

$$r_1 = \sqrt{.035^2 + .020^2} = 4.03\ cm = .0403\ m$$

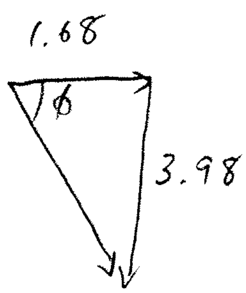


$$|E_1| = \frac{kq_1}{r_1^2} = \frac{(9\times10^9)(3.5\times10^{-6})}{.0403^2} = 1.94\times10^7\ N/C$$

$$|E_2| = \frac{kq_2}{r_2^2} = \frac{(9\times10^9)(2.2\times10^{-6})}{.020^2} = 4.95\times10^7\ N/C$$

$$E_{TOT,x} = E_{1,x} = 1.94\times10^7 \cos 29.7 = 1.68\times10^7$$

$$E_{TOT,y} = E_{1,y} + E_{2,y} = 1.94\times10^7 \sin 29.7 - 4.95\times10^7 = -3.98\times10^7$$

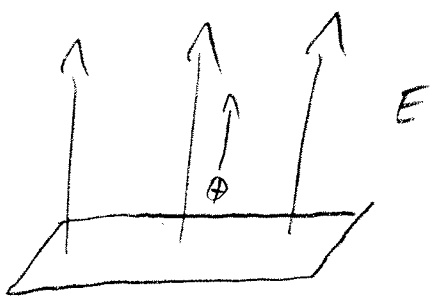


$$|E| = \sqrt{1.68^2 + 3.98^2} = 4.32\times10^7\ N/C$$

$$\phi = \tan^{-1}\left(\frac{3.98}{1.68}\right) = 67^\circ \text{ below } +x$$

2. (40 pts) A plate with area 5.0 cm^2 carries a positive charge of 0.24 nC. You may assume the electric field is uniform in the region close to the plate. A proton starts from rest at a point 3.3 mm above the center of the plate and accelerates away from the plate to a point 8.5 mm above the center. What is the final velocity of the proton?

$$E = 2\pi k \frac{Q}{A} = \frac{2\pi(9\times10^9)(0.24\times10^{-9})}{5.0\times10^{-4}} = 2.7\times10^4 \frac{V}{m}$$



$$\Sigma W_f = W_E = \Delta K$$

$$-\Delta U_E = \Delta K$$

$$-q\Delta V = \Delta K$$

$\Delta V = -Ed$ (negative since + moves from higher to lower V when following $\vec{E}$ line)

$qEd = \frac{1}{2}mv^2 - 0$ ← starts at rest

$$(1.60\times10^{-19})(2.7\times10^4)(5.2\times10^{-3}m) = \frac{1}{2}(1.67\times10^{-27})v^2$$

$$2.246\times10^{-16} = .835\times10^{-27}\ v^2$$

$$2.69\times10^{10} = v^2$$

$$\boxed{v = 1.6\times10^5\ m/s}$$

$a = 2.58\times10^{12}\ m/s^2$

3. (30 pts) The resistivity of copper is 1.7 x 10^{-8} Ohm-m. Suppose you have a household wire with a diameter of 1.0 mm and length 45 meters and current of 11 Amps running through it. If the cost of energy is 12 cents/kW-hr, find out how much money is being lost due to the power dissipated by the resistance of the wire each day, to the nearest penny.

$$R = \frac{\rho l}{A} = \frac{(1.7 \times 10^{-8})(45)}{\frac{\pi (.001)^2}{4}} = 0.974$$

$$P = I^2 R = 118\ W$$

$$E = P \cdot t$$

$$= 118\ \frac{J}{s} \cdot \frac{86400\ s}{day} = 1.02 \times 10^7\ \frac{J}{day}$$

$$Cost = \frac{1.02 \times 10^7\ J}{day} \cdot \frac{1\ kW \cdot hr}{3.60 \times 10^6\ J} \cdot \frac{12\ c}{kW \cdot hr}$$

$$= \boxed{34\ \frac{cents}{day}}$$