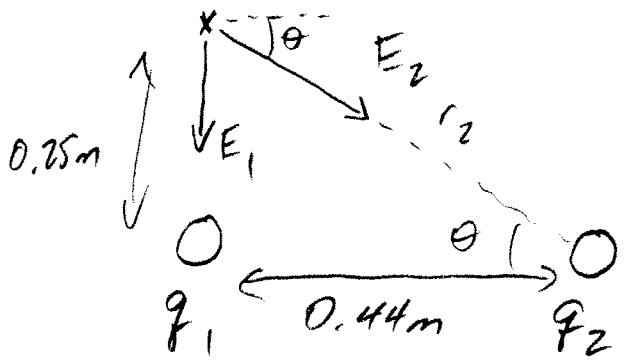
Physics 10164 - Exam 1B

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 -4.5 nC charge is located at the origin. A -6.3 nC charge is located at the coordinate x = 44 cm. What is the magnitude and direction of the electric field at the coordinate y = 25 cm?



$r_2 = \sqrt{.44^2 + .25^2} = .506\ m$

$\theta = \tan^{-1}\left(\frac{.25}{.44}\right) = 29.6°$

$|E_1| = \frac{kq_1}{r_1^2} = \frac{(9\times10^9)(4.5\times10^{-9})}{.25^2}$

$= 648,\ -y\ dir$

$|E_2| = \frac{kq_2}{r_2^2} = \frac{(9\times10^9)(6.3\times10^{-9})}{.506^2}$

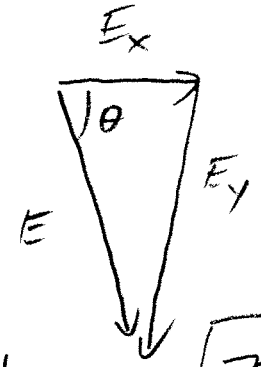
$= 221,\ 29.6°\ below\ +x$

$E_{1x} = 0 \qquad E_{2x} = 221\cos 29.6° = 193$

$E_{1y} = -648 \qquad E_{2y} = -221\sin 29.6° = -109$

$E_{TOT,x} = 193$

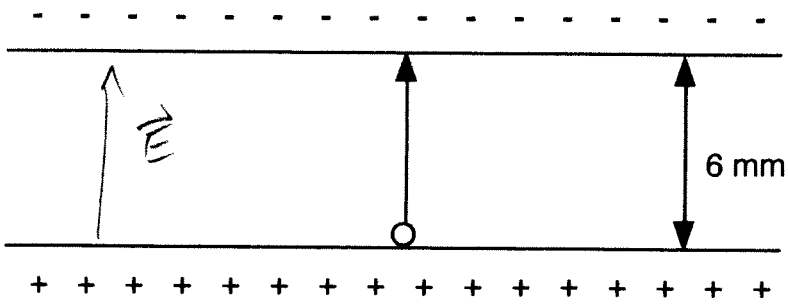
$E_{TOT,y} = -757$



$|E| = \sqrt{193^2 + 757^2} = 781$ or $\boxed{780\ V/m}$

$\theta = \tan^{-1}\left(\frac{757}{193}\right) = \boxed{76°\ below\ +x}$

2. (30 pts) Two parallel plates are separated by 6.0 mm, and a 240 V voltage is applied across the plates. A ball with a mass of 12 grams and a charge of +5.0 μC charge starts at the positive plate at rest. How much time passes before the ball strikes the negative plate?



$$E = \frac{240}{.006} = 40{,}000 \frac{V}{m}$$

$$\Sigma W_F = W_{grav} + W_E = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$$

$$W_{grav} = -mgh = -(.012)(9.8)(.006) = -7.06 \times 10^{-4} J$$

$$W_E = qEh = (5 \times 10^{-6})(40{,}000)(.006) = 1.2 \times 10^{-3} J$$

$$-0.706 \times 10^{-3} + 1.2 \times 10^{-3} = \frac{1}{2}(.012)v^2$$

$$4.94 \times 10^{-4} = (.006)v^2$$

$$\boxed{v = 0.29 \ m/s}$$

$$\Delta x = \frac{1}{2}(v + v_0)t$$

$$.006 = \frac{1}{2}(0.29)t$$

$$t = \frac{.012}{0.29} = \boxed{.041 s}$$

3. (30 pts) A cylindrical wire has a resistivity of 1.5×10^{-8} Ohm-meters, a length of 25 meters and a diameter of 0.85 mm.

a) What is the resistance of the wire?

b) If a potential difference of 120 Volts is applied to the ends of the wire, how much power is dissipated by the wire due to resistive heating?

c) If energy costs 15 cents per kilowatt-hour, how much money will it cost to maintain this system for 14 days?

a) $A = \frac{\pi (.85 \times 10^{-3})^2}{4} = 5.67 \times 10^{-7} m^2$

$R = \frac{\rho l}{A} = \frac{(1.5 \times 10^{-8})(25)}{5.67 \times 10^{-7}} = \boxed{0.66 \Omega}$

b) $P = \frac{\Delta V^2}{R} = \frac{120^2}{0.66} = 21,790 \text{ Watts}$

or $\boxed{22,000 \text{ Watts}}$

c) $E = P \cdot t \quad t = 14 \text{ days} \cdot \frac{86400 s}{\text{day}} = 1.21 \times 10^6 s$

$E = (22000)(1.21 \times 10^6) = 2.66 \times 10^{10} J$

$\text{Cost} = 2.66 \times 10^{10} J \cdot \frac{15 ¢}{3.60 \times 10^6 J} = \boxed{1.11 \times 10^5 ¢}$

or 1110 dollars (!)