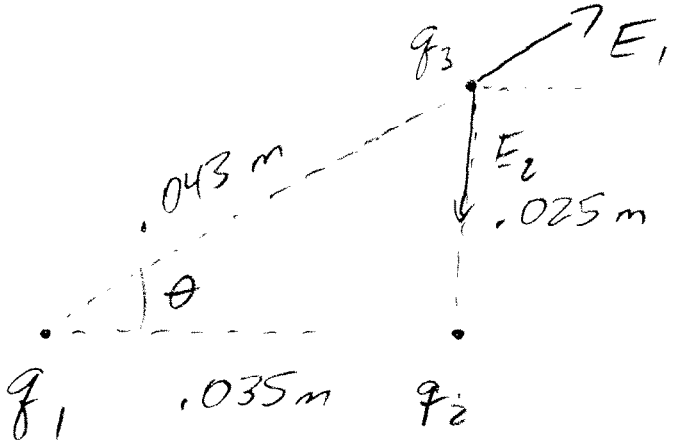
Physics 10164 - Exam 1D

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 +1.5 μC charge is located at the origin. A -2.2 μC charge is located on the x-axis at x = 3.5 cm. Find the magnitude and direction of the total electric force on a +3.1 μC charge located at (x,y) = (3.5 cm, 2.5 cm).



$\theta = \tan^{-1}\left(\frac{.025}{.035}\right)$

$= 35.54°$

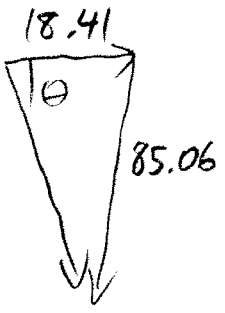
$|F_1| = \frac{kq_1q_3}{r_1^2} = \frac{(9\times10^9)(1.5\times10^{-6})(3.1\times10^{-6})}{.043^2}$ $= 22.63 \frac{V}{m}$

$|F_2| = \frac{kq_2q_3}{r_2^2} = 98.21 \frac{V}{m}$

$E_{TOT,x} = E_{1,x} + E_{2,x} = 22.63 \cos 35.54° + 0$

$= \underline{18.41}$

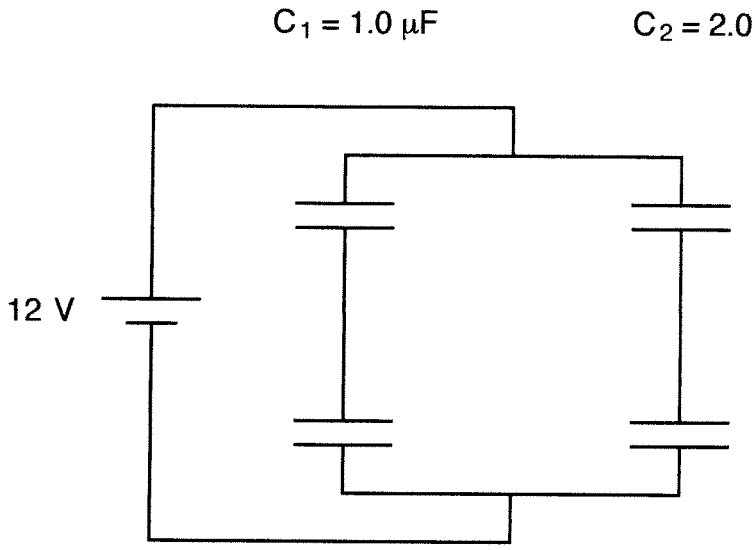
$E_{TOT,y} = 22.63 \sin 35.54° - 98.21 = \underline{-85.06}$



$|E| = \sqrt{18.4^2 + 85.1^2} = \boxed{87 \frac{V}{m}}$

$\theta = \tan^{-1}\left(\frac{85.06}{18.41}\right) = \boxed{78° \text{ below } +x}$

2. (40 pts) A system of four capacitors is arranged as shown below. Find the charge carried by each capacitor.



$$\frac{1}{C_{13}} = \frac{1}{1} + \frac{1}{3}$$

$$C_{13} = 0.75\,\mu F$$

$$\frac{1}{C_{24}} = \frac{1}{2} + \frac{1}{4}$$

$$C_{24} = 1.33\,\mu F$$

$$C_{TOT} = C_{13} + C_{24} = 2.08\,\mu F$$

$$Q_{TOT} = C_{TOT}\,\Delta V_{TOT} = 24.96\,\mu C \approx 25\,\mu C$$

$\Delta V_{13} = 12$ Volts, so $Q_{13} = 9\,\mu C$

so $Q_{13} = \boxed{Q_1 = Q_3 = 9\,\mu C}$

$\Delta V_{24} = 12$ Volts, so $Q_{24} = 15.96\,\mu C$

so $Q_{24} = \boxed{Q_2 = Q_4 = 16\,\mu C}$

3. (30 pts) The resistivity of silver is 1.59 x 10^{-8} Ohm-m. Suppose you have a household wire with a diameter of 1.20 mm and length 12.0 meters and current of 9.50 Amps running through it. If the cost of energy is 12.0 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 cent.

$$A = \frac{\pi (.0012)^2}{4} = 1.131 \times 10^{-6}\ m^2$$

$$R = \rho \frac{l}{A} = 0.169\ \Omega$$

$$P = I^2 R = 15.2\ \text{Watts}$$

$$E(\text{day}) = \frac{15.2\ J}{s} \cdot \frac{86400\ s}{\text{day}} = \frac{1.315 \times 10^6\ J}{\text{day}}$$

$$\text{cost} = \frac{1.315 \times 10^6\ J}{\text{day}} \cdot \frac{1\ kWhr}{3.6 \times 10^6\ J} \cdot \frac{12\ ¢}{kWhr}$$

$$= 4.4\ ¢ \quad \text{or} \quad \boxed{4\ ¢}$$