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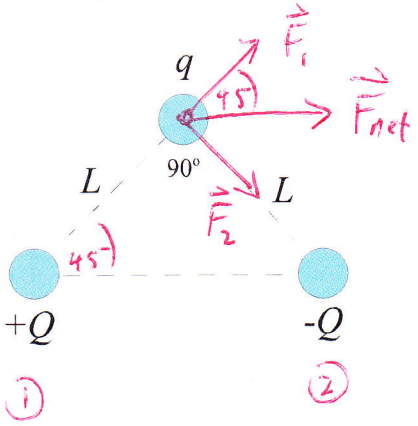
1. Consider the figure below. If $Q = 25.0\ \mu C$, $q = 10.0\ \mu C$, and $L = 40$ cm, find the magnitude and direction of the electrostatic force on q. **(5 marks)**



vertical components cancel

$$|\vec{F}_1| = |\vec{F}_2| = \frac{k_e q Q}{L^2}$$

$$F_{1x} = F_{2x} = \frac{k_e q Q}{L^2}\cos 45^\circ = \frac{k_e q Q}{\sqrt{2}L^2}$$

$$\therefore F_{net,x} = F_{1x} + F_{2x} = \frac{\sqrt{2}\, k_e q Q}{L^2}$$

$$\text{or } \vec{F}_{net} = \frac{\sqrt{2}\, k_e q Q}{L^2}\hat{i} = \boxed{19.9\ N\ \hat{i}}$$

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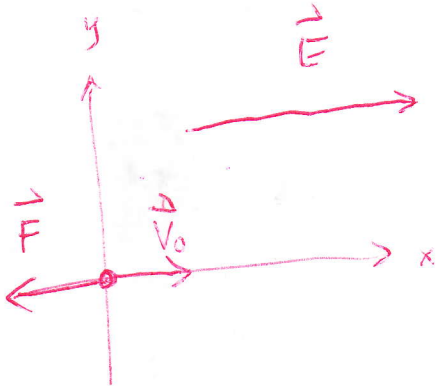
2. A particle ($m = 0.020$ g, $q = -5.00$ μC) moves in a uniform electric field of 60.0 N/C that points in along the positive x-axis. At $t = 0$, the particle is moving 30.0 m/s in the positive x-direction and is passing through the origin. Determine the maximum distance beyond $x = 0$ that the particle travels in the positive x direction. (**4 marks**)



$\vec{F} = m\vec{a} = q\vec{E}$

$\therefore \vec{a} = \frac{q}{m}\vec{E}$ const. acceleration.

$V^2 = V_0^2 + 2ad$

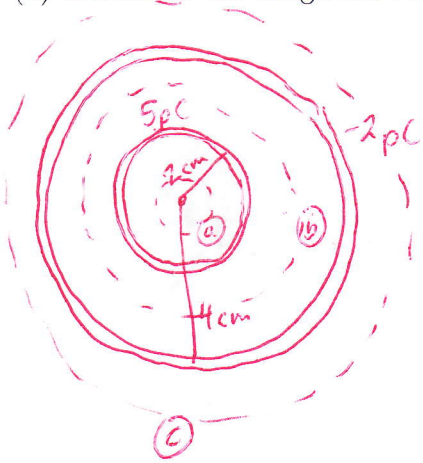
$V = 0$

$\therefore d = \frac{V^2 - V_0^2}{2a}$

$\therefore d = \frac{-V_0^2}{2a} = \frac{-mV_0^2}{2qE} = \boxed{30.0\ \text{m}}$

3. A charge of 5.00×10^{-12} C is distributed uniformly on the surface of a spherical shell (radius $a = 2.00$ cm), and a second charge of -2.00×10^{-12} C is distributed uniformly on a concentric spherical shell (radius $b = 4.00$ cm). (**6 marks**)

(a) Determine the magnitude of the electric field 1.00 cm from the centre of the two spheres.



$q_{inside} = 0 \quad \therefore \boxed{\vec{E} = 0}$

(b) Determine the magnitude of the electric field 3.00 cm from the centre of the two spheres.

$q_{inside} = 5.00 \times 10^{-12}\ C \Rightarrow$ like pt. charge $r = 3.00$ cm

$\vec{E} = \frac{k_e q_{inside}}{r^2} \hat{r}$ ← radial dir'n

$|\vec{E}| = \frac{k_e q_{inside}}{r^2} = 49.9 \frac{N}{C}$

(c) Determine the magnitude of the electric field 5.00 cm from the centre of the two spheres.

$q_{inside} = 5.00 \times 10^{-12}\ C - 2.00 \times 10^{-12}\ C = 3.00 \times 10^{-12}\ C$

like a pt. charge $r = 5.00$ cm

$|\vec{E}| = \frac{k_e q_{inside}}{r^2} = \boxed{10.8 \frac{N}{C}}$

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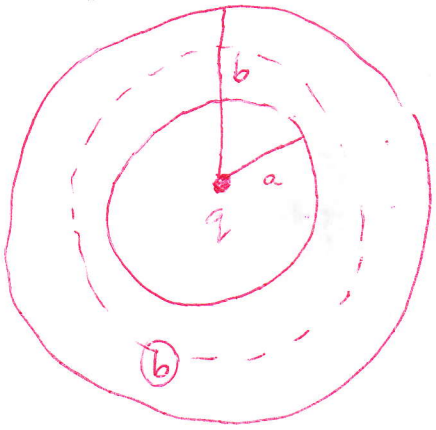
4. A point charge of 6.0 nC is placed at the center of a hollow spherical conductor (inner radius $a = 1.00$ cm and outer radius $b = 2.00$ cm) which has a net charge of -4.00 nC. **(5 marks)**

(a) What is the electric field inside the conductor a distance $r = 1.50$ cm from the centre of the spherical shell?



inside conductor $\vec{E} = 0$

(b) What is the charge density (charge per unit area) on the inner surface of the conducting sphere?

$q_{inside} = 0$ since $\vec{E} = 0$ $\int_{surface} \vec{E} \cdot d\vec{a} = \frac{q_{inside}}{\varepsilon_0}$

$q_{inside} = q + q_{inner} = 0$ $\therefore$ $q_{inner} = -q = -6.00\,nC$

(q: pt. charge; q_{inner}: inner surface shell)

$\sigma = \frac{charge}{area} = \frac{q_{inner}}{4\pi a^2} = \frac{-q}{4\pi a^2} = -4.77 \times 10^{-6}\ \frac{C}{m^2}$

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