Electostatics: Charges in Uniform fields

Classical Mechanics Applied to Tiny Invisible Objects!

① a. $\vec{d} = \left(\frac{\vec{v} + \vec{v}_0}{2}\right)t = 7.5 \times 10^{7}\ m$

b. $\vec{a} = \frac{\Delta\vec{v}}{t} = 6.0 \times 10^{6}\ m/s^2$

$\Sigma\vec{F} = m\vec{a}$

$qE = ma$

$E = \frac{ma}{q} = \frac{1.67 \times 10^{-27} kg\,(6 \times 10^{6} m/s^2)}{1.60 \times 10^{-19} C} = 0.063\ N/C$

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② a. $7.5 \times 10^{7}\ m$

b. $E = \frac{ma}{q} = \frac{9.11 \times 10^{-31} kg\,(6 \times 10^{6} m/s^2)}{1.60 \times 10^{-19} C} = 0.000034...\ N/C = 3.4 \times 10^{-5}\ N/C$

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③ a. $\vec{F}_e$ must be up to suspend the sphere against $\vec{F}_g$.

If $\vec{E}$ is down and $\vec{F}_e$ is up, q MUST BE NEGATIVE

b. $\vec{E}$ points from + to − ⇒ TOP PLATE IS POSITIVE

c.

$\Sigma\vec{F} = 0$

$F_e = mg$

$qE = mg$

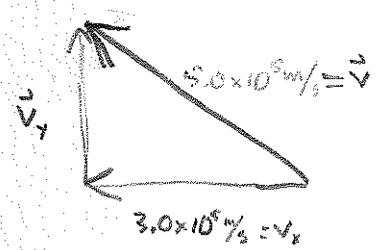
$q = \frac{mg}{E} = \frac{1.0 \times 10^{-3} kg\,(9.8\ m/s^2)}{1.0 \times 10^{4}\ N/C} = -9.8 \times 10^{-7}\ C$

d. $-9.8 \times 10^{-7} C \times \left(\frac{1\ \text{electron}}{-1.60 \times 10^{-19} C}\right) = 6.1 \times 10^{12}$ electrons

④ * Force on ⊕ is upward (+y) so x-velocity is unaffected.

$\Rightarrow \vec{v}_x = 3.0\times10^5\ m/s$

$\Rightarrow$



$v_y = \sqrt{v^2 - v_x^2}$ ← Pythagora's Theorem

$v_y = 4.0\times10^5\ m/s$

$\hat{x}$: $\vec{v}_x = 3.0\times10^5\ m/s$

$\vec{d}_x = 5.0\times10^{-2}\ m$

$t = \dfrac{d_x}{v_x} = 1.\bar{6}\times10^{-7}\ s$

$\hat{y}$: $\vec{v}_{oy} = 0$

$\vec{v}_y = 4.0\times10^5\ m/s$

$t = 1.\bar{6}\times10^{-7}\ s$

$\vec{a}_y = ?$

$\vec{a} = \dfrac{\Delta\vec{v}}{t}$

$\vec{a}_y = 2.4\times10^{12}\ m/s^2$

$\Sigma\vec{F} = m\vec{a}$

$qE = ma$

$E = \dfrac{ma}{q} = \dfrac{1.67\times10^{-27}\ kg\,(2.4\times10^{12}\ m/s^2)}{1.60\times10^{-19}\ C} = 25050\ N/C$

$\vec{E} = 25\,000\ N/C$ up.

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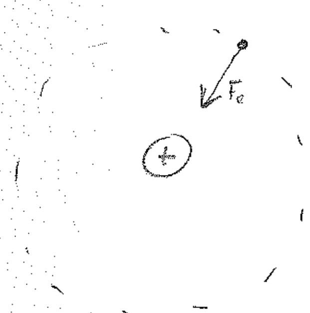
⑤



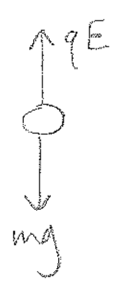
$\Sigma\vec{F} = m\vec{a}$

$\dfrac{kQq}{r^2} = \dfrac{mv^2}{r}$ (circular motion!)

$v = \sqrt{\dfrac{kQq}{mr}}$

$v = 2.2\times10^6\ m/s$

⑥ similar to #3



$$\Sigma \vec{F} = 0$$

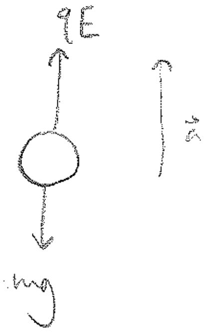
$$qE = mg$$

$$q = \frac{mg}{E}$$

$$q = \frac{0.0020\,kg\,(9.8\,N/kg)}{3000\,N/C} = 6.5\bar{3} \times 10^{-6}\,C$$

$$q = +6.5\,\mu C$$

b.



$$\Sigma \vec{F} = ma$$

$$qE - mg = ma$$

$$qE = ma + mg$$

$$E = \frac{m(a+g)}{q}$$

$$E = 5448.979592$$

$$\vec{E} = 5400\,N/C \text{ up}$$