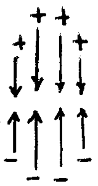
PS #1 Sol'ns PHYS 232

23-4) $F_{2p} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2} = (8.99\times10^9\ N\cdot\frac{m^2}{C^2})\cdot\left(\frac{1.60\times10^{-19}C}{2.00\times10^{-15}m}\right)^2 \simeq \boxed{57.54\ N}$

pretty big for two little guys!

13-8) 

ese are
e force
vectors!

H has 2 particles /atom ; 1 $e^-$ & 1 p.

$N_A = 6.02\times10^{23}$ particles/mol , molar mass $\simeq$ 1.0 g/mol ; m = 1.0g

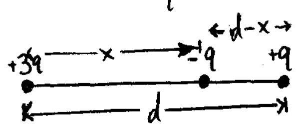
$\Rightarrow N_{e^-} = N_p \simeq 3.01\times10^{23}$

This problem can be made complicated, so let's make some assumptions to make life easier. There is a repulsive force between the particles at both poles which causes them to spread out. We can rightly assume that their spacing is negligible compared to the distance between the poles. This gives: $\theta \simeq 0 \Rightarrow \cos\theta \simeq 1$

minus sign indicates a compressional force!

$$\Rightarrow \vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{(N_p e)(N_e(-e))\hat{r}}{(2r_E)^2} = \frac{-1}{16\pi\varepsilon_0}\cdot\frac{N^2e^2\hat{r}}{(6.37\times10^6 m)^2} \simeq \boxed{-(1.28\times10^5 N)\hat{r}}$$

23-10) All motion is confined to the x-direction. The position of stable equilibrium is that at which the net force is zero:




$$\Rightarrow \frac{1}{4\pi\varepsilon_0}\frac{3q(-q)}{x^2} = \frac{1}{4\pi\varepsilon_0}\frac{q(-q)}{(d-x)^2}$$

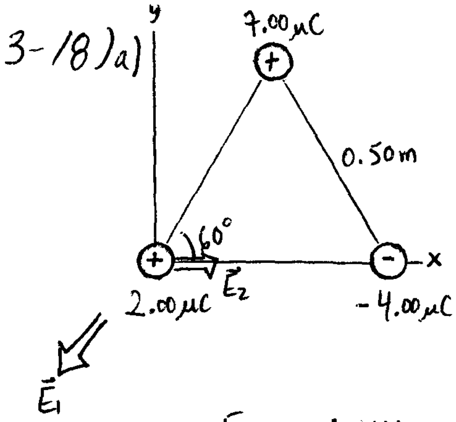
$$3(d-x)^2 = x^2 \Rightarrow 3d^2 - 6dx + 3x^2 = x^2$$

$$\Rightarrow 2x^2 - 6dx + 3d^2 = 0$$

$$\Rightarrow x = \frac{+6d \pm \sqrt{36d^2 - 24d^2}}{4} = \frac{3}{2}d \pm \frac{\sqrt{3}\,d}{2}$$

The positive radical yields a value greater than d, therefore: $\boxed{x = \frac{d}{2}(3-\sqrt{3})}$

3-18)a)




$$\vec{E}_1 = \frac{\hat{r}_1}{4\pi\varepsilon_0}\cdot\frac{(7.00\times10^{-6}\,C)}{(0.5\,m)^2} \simeq 2.5\times10^5\,\frac{N}{C}\,\hat{r}_1$$

$$\vec{E}_2 = \frac{\hat{r}_2}{4\pi\varepsilon_0}\cdot\frac{(-4.0\times10^{-6}C)}{(0.5\,m)^2} \simeq -1.44\times10^5\,\frac{N}{C}\,\hat{r}_2\,;\ \hat{r}_2 = -\hat{x}$$

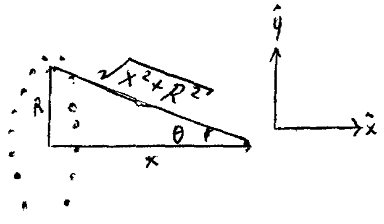
$$E_x = 1.44\times10^5\,\frac{N}{C} - (\cos 60°)(2.5\times10^5\,\frac{N}{C}) \simeq 1.8\times10^4\,\frac{N}{C}$$

$$E_y = -(\sin 60°)(2.5\times10^5\,\frac{N}{C}) \simeq -2.18\times10^5\,\frac{N}{C}$$

$$\Rightarrow \vec{E} = (1.8\times10^4\,\tfrac{N}{C})\hat{i} - (2.18\times10^5\,\tfrac{N}{C})\hat{j} \simeq \boxed{2.19\times10^5\,\tfrac{N}{C}\text{ at }275°}$$

23-18)b) $\vec{F} = q\vec{E} = (2.00\times10^{-6}C)(2.19\times10^5\,\frac{N}{C}\ @\ 275°) \simeq \boxed{0.438\,N\ @\ 275°}$

23-23)a)




for one charge: $d\vec{E} = \frac{Q}{4\pi n\varepsilon_0}\,\frac{1}{(x^2+R^2)}$

$$dE_x = dE\cos\theta = \frac{Q}{4\pi n\varepsilon_0}\,\frac{x}{(x^2+R^2)^{3/2}}$$

$$\cos\theta = \frac{a}{h} = \frac{x}{\sqrt{x^2+R^2}}$$

this is not necessarily in the $\hat{y}$-direction above; rather, it's ∥ to the plane of the circle!

$$dE_y = dE\sin\theta = \frac{Q}{4\pi\varepsilon_0 n}\,\frac{R}{(x^2+R^2)^{3/2}}$$

Due to the symmetry of the above configuration, all of the "y-components" of the electric field cancel & we have:

$$\boxed{\vec{E} = \sum_{i=1}^{n}\frac{Q_i}{4\pi\varepsilon_0 n}\,\frac{\hat{r}_i}{r^2} = \frac{Q}{4\pi\varepsilon_0}\,\frac{x\,\hat{x}}{(x^2+R^2)^{3/2}}}$$

23-23)b) The above problem is an example of how symmetry plays a significant role in electrostatics. Due to the circular configuration, the vertical components of the field cancel. In the limit of large n, the distribution will be continuous: this is the subject matter of Ex. 23.8.

DS #1 Sol'ns PHYS 232

23-51) a) Apply the eqns. of kinematics in 1-D:

$$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$v_0 = 0$$

$$ma = qE \Rightarrow a = \frac{qE}{m}$$

For the proton: $x_f = \frac{q_p E}{2m_p} t^2$ (distance from pos. plate)

" " electron: $x_f = \frac{q_e E}{2m_p} t^2 + x_0$ ( " " neg. " )

$x_0 = 4\,cm$, $q_p = e$, $q_e = -e$

The cond'n to be satisfied is: $\frac{eE}{2m_p} t^2 = x_0 - \frac{eE}{2m_e} t^2$

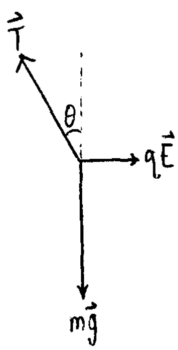
$$\Rightarrow t^2 = \frac{2x_0}{eE}\left(\frac{m_e m_p}{m_e + m_p}\right)$$

Meeting pt. is $\Rightarrow$ $x_f = \left(\frac{eE}{2m_p}\right)\left(\frac{2x_0}{eE}\right)\left(\frac{m_e m_p}{m_e + m_p}\right) = \frac{x_0 m_e}{m_e + m_p} \simeq \boxed{21.77\,\mu m}$

23-51) b) By construction:

$$x_f = \frac{x_0 m_{Cl^-}}{m_{Na^+} + m_{Cl^-}} \simeq \boxed{2.43\,cm}$$

23-54)




$T\cos\theta = mg \Rightarrow T = (mg/\cos\theta)$

$T\sin\theta = mg\tan\theta = qE$

$$\Rightarrow \boxed{q = \frac{mg\tan\theta}{E} \simeq 5.26\,\mu C}$$