2.

a) $10g \times \frac{1\ mol}{107.87\ g} \times \frac{6.02 \times 10^{23}\ atoms}{1\ mol} \times \frac{47\ e^-}{1\ atom} = 2.62 \times 10^{24}$

b) $1mC = 10^{-3}C$

$10^{-3}C \times \frac{1\ electron}{1.6 \times 10^{-19}C} = 6.25 \times 10^{15}\ e^-$ added total

ratio of e added to those present $\frac{6.25 \times 10^{15}}{2.62 \times 10^{24}} = 2.39 \times 10^{-9}$

so for each 10^9 present $10^9 \times 2.39 \times 10^{-9} = 2.39\ e^-$ added

4. $F = \frac{k q_1 q_2}{r^2} = \frac{(8.97 \times 10^9)(1.6 \times 10^{-19})^2}{(2 \times 10^{-15})^2} = 57.54\ N$

5. In Book

7.

a) $F = \frac{K q_1 q_2}{r^2} = \frac{(8.99 \times 10^9)(12 \times 10^{-9})(-18 \times 10^{-9})}{(.3)^2}$

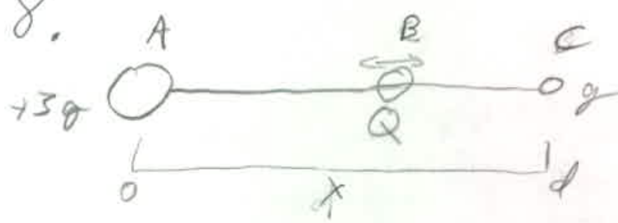
$= -2.16 \times 10^{-5}$ the force is negative so it is attractive

b) when we connect the spheres, the charge evens out

$F = \frac{k q_1 q_2}{r^2} = \frac{(8.99 \times 10^9)(-3 \times 10^{-9})^2}{(.3)^2} = 8.99 \times 10^{-7}\ N$

The force is positive, so it is repulsive

8.



the system will be in equilibrium when the forces on Q are equal

$$F_{AB} = \frac{k(3q)Q}{x^2} \qquad F_{BC} = \frac{k(q)Q}{(d-x)^2}$$

$$F_{AB} = F_{BC} \Rightarrow \frac{K(3q)Q}{x^2} = \frac{k(q)Q}{(d-x)^2}$$

$$\frac{3}{x^2} = \frac{1}{(d-x)^2}$$

$$3(d-x)^2 = x^2$$

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

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

$$\frac{6d \pm \sqrt{36d^2 - 4(2)(3d^2)}}{4} = \frac{3d}{2} \pm \frac{d\sqrt{36-24}}{4}$$

$$= \frac{3d}{2} \pm \frac{d\sqrt{3}}{2} = \left(\frac{3 \pm \sqrt{3}}{2}\right)d$$

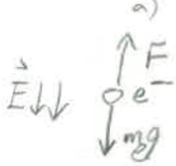
$\left(\frac{3+\sqrt{3}}{2}\right)d$ is outside the rod, so not possible

$\left(\frac{3-\sqrt{3}}{2}\right)d$ is on the rod, and there fore possible

The equilibrium is stable if Q is positive, unstable if Q is negative

10. $F = q\vec{E}$ to balance weight

a)



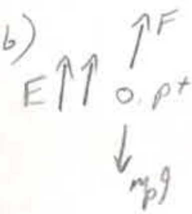
$$q_e E = m_e g$$

$$E = \frac{9.11 \times 10^{-31}(9.8)}{1.6 \times 10^{-19}}$$

$$E = -5.58 \times 10^{-11}\, N/C\ \hat{z}$$

$-\hat{z}$ direction since e^- have negative charge

b)



$$q_p E = m_p g$$

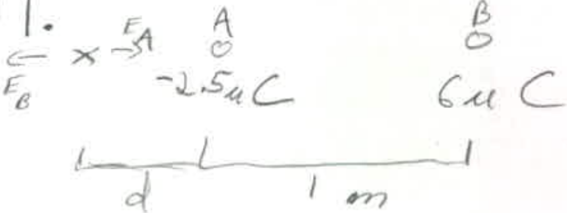
$$E = \frac{m_p g}{q_p}$$

$$E = \frac{(1.67 \times 10^{-27})\, 9.8}{1.6 \times 10^{-19}}$$

$$E = 1.02 \times 10^{-7}\, N/C\ \hat{z}$$

$\hat{z}$ direction since protons are positively charged

11.



$$\vec{E}_T = \vec{E}_A + \vec{E}_B$$

$$\vec{E}_T = 0 = \vec{E}_A + \vec{E}_B$$

$$0 = \frac{k q_a}{r_a^2} + \frac{k q_b}{r_b^2}$$

$$0 = k\left[\frac{2.5\mu C}{d^2} - \frac{6\mu C}{(d+1)^2}\right]$$

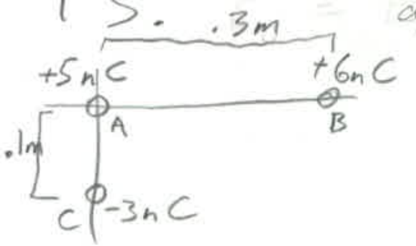
$$6(d)^2 = 2.5(d+1)^2 = 2.5(d^2+2d+1)$$

$$-3.5d^2 + 5d + 2.5 = 0$$

$$d = \frac{-5 \pm \sqrt{25 + 4(\frac{7}{2})(\frac{5}{2})}}{-7} = \frac{5 \pm 2\sqrt{15}}{7} = 1.82\,m$$

the answer is $\frac{5+2\sqrt{15}}{7}$ because $\frac{5-2\sqrt{15}}{7}$ is between the two charges and the field can't possibly be zero in between them.

13.



a) $$\vec{E}_0 = \vec{E}_{BA} + \vec{E}_{CA}$$

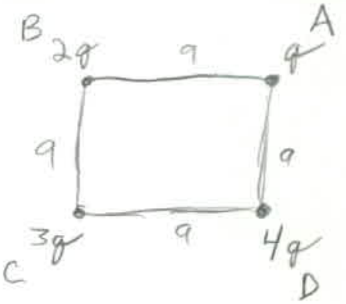
$$= \frac{k q_b}{r_{BA}^2}\,-\hat{x} + \frac{k q_c}{r_{CA}^2}\,-\hat{y}$$

$$= -\frac{k(6nC)}{.3^2}\hat{x} - \frac{k(3nC)}{(.1)^2}\hat{y} = -599.\overline{3}\,\hat{x} - 2697\,\hat{y}\ N/C$$

b) $$\vec{F}_A = \vec{F}_{BA} + \vec{F}_{CA}$$

$$= -\frac{k q_B q_A}{r_{BA}^2}\hat{x} - \frac{k q_C q_A}{r_{CA}^2}\hat{y} = -\frac{k(6nC)(5nC)}{.3^2}\hat{x} - \frac{k(3nC)(5nC)}{.1^2}\hat{y}$$

$$\vec{F}_A = -3\times10^{-6}\,\hat{x} - 13.5\times10^{-6}\,\hat{y}\ N$$

15. 

a) $E_A = \vec{E}_{BA} + \vec{E}_{CA} + \vec{E}_{DA}$

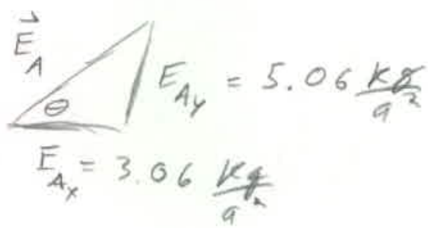
$\vec{E}_{BA} = \frac{K(2q)}{a^2}\hat{x}$

$\vec{E}_{DA} = \frac{K(4q)}{a^2}\hat{y}$ $\qquad \vec{E}_{CA} = \frac{K(3q)}{(\sqrt{2}a)^2}(\cos 45\hat{x} + \sin 45\hat{y})$

$\cos 45 = \sin 45 = \frac{\sqrt{2}}{2}$

$E_A = \frac{Kq}{a^2}\left[\left(2 + \frac{3}{2}\frac{\sqrt{2}}{2}\right)\hat{x} + \left(4 + \frac{3}{2}\frac{\sqrt{2}}{2}\right)\hat{y}\right]$

$\vec{E}_A = \frac{Kq}{a^2}\left[3.06\hat{x} + 5.06\hat{y}\right]$



$|E_A| = \sqrt{\left(3.06\frac{Kq}{a^2}\right)^2 + \left(5.06\frac{Kq}{a^2}\right)^2} = 5.91\frac{Kq}{a^2}$

$\theta = \tan^{-1}\left(\frac{5.06}{3.06}\right) = 58.84°$

$\vec{E}_A = (5.91)\frac{Kq}{a^2}$ at $58.84°$

b) $\vec{F}_A = \vec{F}_{BA} + \vec{F}_{CA} + \vec{F}_{DA}$

$\vec{F}_{BA} = \frac{K(2q)q}{a^2}\hat{x}$ $\qquad F_{DA} = \frac{K(4q)q}{a^2}$

$\vec{F}_{CA} = \frac{K(3q)q}{(\sqrt{2}a)^2}(\cos 45\hat{x} + \sin 45\hat{y})$

$F_A = \frac{Kq^2}{a^2}\left[\left(2 + \frac{3}{2}\frac{\sqrt{2}}{2}\right)\hat{x} + \left(4 + \frac{3}{2}\frac{\sqrt{2}}{2}\right)\hat{y}\right]$

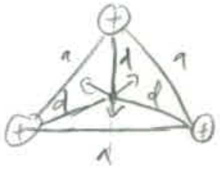
$F_A = 5.91\frac{Kq^2}{a^2}$ N at $58.84°$

24. $\frac{q_1}{q_2} = \frac{-6}{18} = -\frac{1}{3}$ since q_2 emits three times as many field lines

Field lines point away from q_2 so it is positive

Field lines point towards q_1 so it is negative

26. a) The field will be zero at the triangle's centroid.



We can see the x components of the field cancel out along the dotted line. We can check that the y components cancel at the centroid.

$$E = \frac{-kq}{d^2} + \frac{2kq}{d^2}\sin(30) = \frac{kq}{d^2}\left[-1 + 2(\tfrac{1}{2})\right] = 0 \quad ✓$$

b) Again from symmetry the field will cancel out in the x direction, but just to check:

$$E_x = \frac{kq}{a^2}\cos 60\,\hat{x} - \frac{kq}{a^2}\cos 60\,\hat{x} = 0$$

$E_y = \frac{2kq}{a^2}\sin 60\,\hat{y}$ which is also the total field at P

27. In Book

29.

a) $x = V_x t$

$.05 = 4.5\times10^5\, t$

$t = 1.11\times10^{-7}$

b) $F = qE$

$= (1.6\times10^{-19})(9.6\times10^{3}) = 1.536\times10^{-15}$

$F = m_p a$

$1.54\times10^{-15} = (1.67\times10^{-27})a$

$a = 9.22\times10^{11}\ m/s^2$

$y_f = y_0 + V_{0y}t + \frac{1}{2}a_y t^2$

$y_f = 0 + 0 + \frac{1}{2}(9.22\times10^{11})(1.11\times10^{-7})^2$

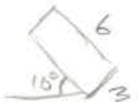
$y_f = 5.67\times10^{-3}\ m$

c) The horizontal component is unchanged since there is no force or acceleration in that direction

$V_y = a_y t = (9.22\times10^{11})(1.11\times10^{-7}) = 102{,}342\ m/s$

so $\vec{V} = 4.5\times10^5\,\hat{x} + 1.02\times10^5\,\hat{y}$

30. $\uparrow\uparrow\vec{E}$



$\text{Flux} = \vec{E} \cdot \text{Area}$

$\text{Area} = 3 \cdot 6\cos(10)$

$\text{Flux} = (2\times10^4)\cdot 3\cdot 6\cos(10) = 3.54\times10^5 \ \frac{N\cdot m^2}{C}$

31. In Book

32. a) $\int E \cdot dA = \frac{q_{enc}}{\varepsilon_0}$

$\varepsilon_0 (890)(4\pi(3/4)^2) = q_{enc} = 5.57\times10^{-8}\,C$

b) It must be spherically symmetric since the magnitude of the field it produces is constant on a sphere surrounding it.

33. In Book

34. b) $\Phi_T = \frac{q_{enc}}{\varepsilon_0} = \frac{170\,\mu C}{\varepsilon_0} = 1.92\times10^7$

a) Each face gets an even $\frac{1}{6}$th of the flux since the charge is in the center

$\Phi_F = \frac{\Phi_T}{6} = 3.2\times10^6$

c) part b would not change, the answer to part a would change since the faces would no longer have equal flux through them

54. The object is stationary so Forces in x direction sum to 0

$T_x = \tan(15)\, mg\, (-\hat{x})$

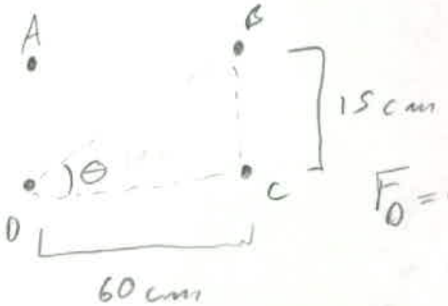
$F_x + T_x = 0$

$F_x = -T_x = mg \tan 15$

$F_x = \vec{E} q$

$q = \dfrac{mg \tan(15)}{E} = 5.25 \times 10^{-6}\, C$

55.



$F_D = F_{AD} + F_{BD} + F_{CD}$

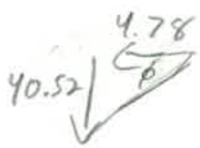
$F_D = \dfrac{k(10\times10^{-6})^2}{(.15)^2}(-\hat{y}) + \dfrac{k(10\times10^{-6})^2}{(\sqrt{.15^2+.60^2})^2}\left(-\cos(14.04)\hat{x} - \sin(14.04)\hat{y}\right)$

$+ \dfrac{k(10\times10^{-6})}{(.6)^2}(-\hat{x})$

$\theta = \tan^{-1}\left(\frac{15}{60}\right) = 14.04°$

$F_D = -4.78\,\hat{x} - 40.52\,\hat{y}$

$|F_D| = \sqrt{(4.78)^2 + (40.52)^2} = 40.8\ N$

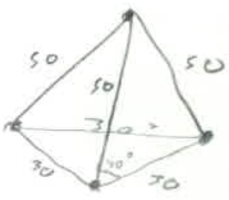


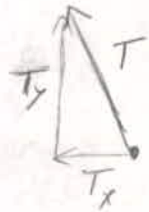
$\phi = \tan^{-1}\left(\frac{40.52}{4.78}\right) = 83.27$

but add 180° since we are in quadrant III

so direction is 263.27°

56.





$T_y = W - F_{E_y}$

$T_x = -F_{E_x}$

$\theta = \cos^{-1}\left(\frac{15}{50}\right) = 72.5°$

$T_y = -mg + \frac{Kq^2}{(.3)^2}\cos(30°)$

$T_x = \frac{-Kq^2}{(.3)^2}\sin(30°) + \frac{-Kq^2}{(.3)^2}$

$\tan\theta = \frac{T_y}{T_x}$

$-\frac{Kq^2}{(.3)^2}(\sin(30°)+1)\tan(107.5°) = -mg + \frac{Kq^2}{(.3)^2}\cos(30°)$

$q^2 = \frac{-mg(.3)^2}{K([-\sin(30)-1]\tan(107.5)-\cos(30))} = 5.04\times10^{-14}$

$q = \pm\ 2.24\times10^{-7}\ C$