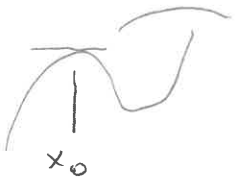
Solutions HW 1

21.1

Use the fact that if $f(x)$ has a maximum at $x = x_0$ then $\frac{df}{dx}(x_0) = 0$



charge on first particle $Q-q$

charge on second particle q

magnitude of force as a function of q

$$|\vec{F}| = \frac{k\,q(Q-q)}{r^2}$$

$$\frac{d|\vec{F}|}{dq} = \frac{k}{r^2}\left((Q-q)-(q)\right) = \frac{k}{r^2}(Q-2q) = 0$$

This vanishes if $2q = Q$ or

$$\boxed{q = \frac{Q}{2}}$$

(21.2) In this problem when a charged ball is put in contact with an identical ball the charge on each ball is half of the total charge on both balls

initially

$$q_1 = q_2 = q \qquad |\bar{F}| = k\frac{q^2}{r^2}$$

after first touch

$$\left.\begin{aligned} q_1 &= \frac{q}{2} \\ q_3 &= \frac{q}{2} \end{aligned}\right\} \text{half total charge on each}$$

$$q_2 = q$$

after second touch

$$q_1 = \frac{q}{2}$$

$$\left.\begin{aligned} q_3 &= \frac{3}{4}q \\ q_2 &= \frac{3}{4}q \end{aligned}\right\} \text{half total charge on each}$$

$$|\bar{F}'| = k\frac{q_1 q_2}{r^2} = k\frac{\frac{q}{2}\left(\frac{3}{4}q\right)}{r^2} = \frac{3}{8}k\frac{q^2}{r^2} = \frac{3}{8}|\bar{F}|$$

$$\frac{|\bar{F}'|}{|\bar{F}|} = \frac{3}{8}$$

21.3) $|F| = k\frac{q_1 q_2}{r^2}$

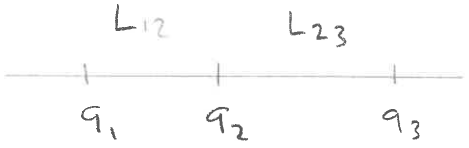
$$r^2 = \frac{k q_1 q_2}{|F|}$$

$$r = \sqrt{\frac{k q_1 q_2}{F}} = \left(\frac{(9\times 10^9 \,N\cancel{m^2/c^2})(2.6\times 10^{-6}\,\cancel{c})(-47.\times 10^{-6}\,\cancel{c})}{5.7\,N}\right)^{1/2}$$

$$= \sqrt{\frac{9\times 2.6\times 47\times 10^{-3}}{5.7}}\ m$$

$$= .439 \text{ meters}$$

21.7



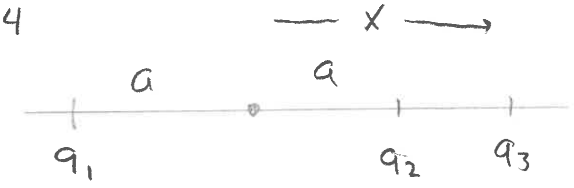
$L_{12} = L_{23} = L$

$$F_3 = k q_3 \left(\frac{q_1}{(L_{12}+L_{23})^2} + \frac{q_2}{(L_{23})^2}\right) = 0$$

$$= k q_3 \left(\frac{q_1}{(2L)^2} + \frac{q_2}{(L)^2}\right) = 0$$

$$\frac{q_1}{4L^2} = -\frac{q_2}{L^2} \qquad \frac{q_1}{q_2} = -4$$

21.14



$$F_3 = k q_3 \left(\frac{q_1}{(x+a)^2} + \frac{q_2}{(x-a)^2} \right) = 0$$

$$q_1 (x-a)^2 = -q_2 (x+a)^2$$

$$\frac{q_1}{q_2} = -\frac{(x+a)^2}{(x-a)^2}$$

case 1 $\quad x = .5a$

$$\frac{q_1}{q_2} = -\frac{(1.5a)^2}{(.5a)^2} = -3^2 = -9$$

case 2

$$\frac{q_1}{q_2} = -\frac{(2.5a)^2}{(1.5a)^2} = -5^2 = -25$$

24)

a) $|\bar{F}| = k\frac{q^2}{r^2} = 9\times10^9 \frac{(-1\times10^{-16})^2}{(10^{-2^2})} N \frac{m^2}{c^2} \times \frac{c^2}{m^2}$

$= 9\times10^{-19} N$

b) $N = 10^{-16}\not{C} \times 6.24\times10^{18} \text{ electron}/\not{\text{coulomb}}$

$= 6.24\times10^{2} \text{ electron}$