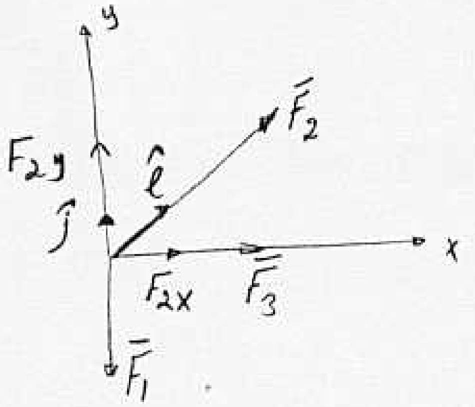
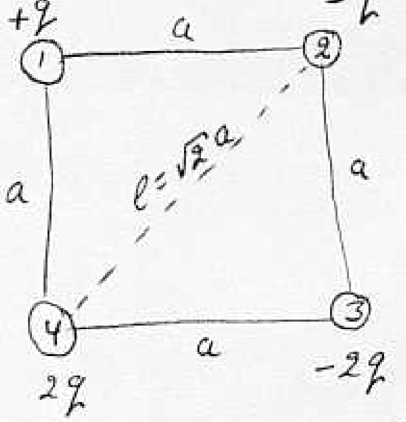
10P. In Fig. 22-23, what are the horizontal and vertical components of the resultant electrostatic force on the charge in the lower left corner of the square if $q = 1.0 \times 10^{-7}$ C and $a = 5.0$ cm?

22-10





$$\bar{F}_1 = k\,\frac{q(2q)}{a^2}\,(-\hat{j})$$

$k = 9\times10^9\ \frac{N.m^2}{C^2}$

$q = 1\times10^{-7}\ C$

$a = 5\times10^{-2}\ m^2$

$$\bar{F}_3 = k\,\frac{(2q)(2q)}{a^2}(\hat{i}) \quad , \quad \bar{F}_2 = k\,\frac{(q)(2q)}{\ell^2}\,\hat{e}$$

$$|F_x| = \bar{F}_3 + \bar{F}_{2x} = k\left[\frac{4q^2}{a^2} + \frac{2q^2}{2a^2}\cos 45^\circ\right] = \frac{kq^2}{a^2}\left[4 + \frac{1}{\sqrt{2}}\right]$$

$= \underline{0.169\,N}$. in positive x-axis

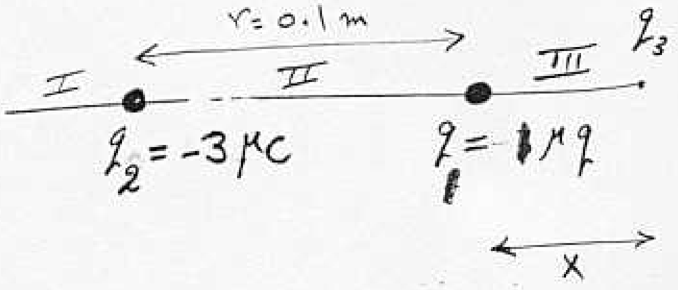
$$|F_y| = F_{2y} - F_1 = \frac{kq^2}{a^2}\left[\frac{1}{\sqrt{2}} - 2\right] = -0.047\,N$$

$|F_y| = \underline{0.047}$ in the negative y-direction.

14P. Two fixed particles, of charges $q_1 = +1.0\ \mu C$ and $q_2 = -3.0\ \mu C$, are 10 cm apart. How far from each should a third charge be located so that no net electrostatic force acts on it?

22-14 the equilibrium will be in region III only.

at region III



$$|F_1| = |F_2|$$

$$k\frac{q_1 q_3}{x^2} = k\frac{q_2 q_3}{(x+r)^2} \Rightarrow x^2 = \frac{q_1}{q_2}(x+r)^2$$

$$x = \pm\frac{1}{\sqrt{3}}(x+r)$$

$$\sqrt{3}\,x = x + r \Rightarrow x = \frac{r}{(\sqrt{3}-1)} = 1.4r = 14\text{ cm}$$ ✓

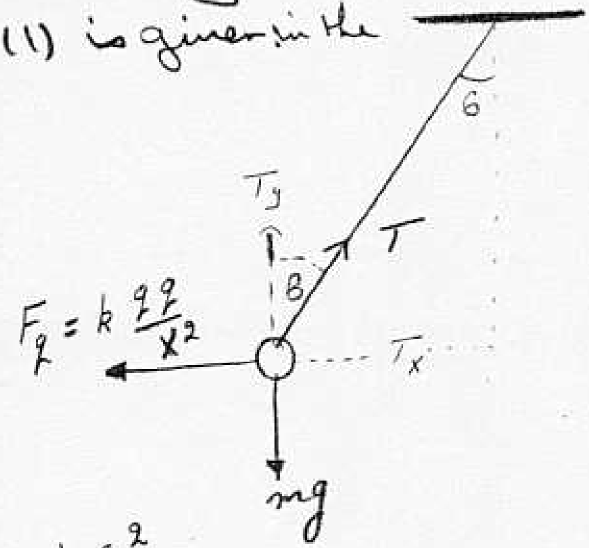
$$\sqrt{3}\,x = -x - r \Rightarrow x = \frac{-r}{(1+\sqrt{3})} = -0.4r = -4\text{ cm}$$ ✗

20P. In Fig. 22-24, two tiny conducting balls of identical mass m and identical charge q hang from nonconducting threads of length L. Assume that θ is so small that $\tan\theta$ can be replaced by its approximate equal, $\sin\theta$. (a) Show that, for equilibrium,

$$x = \left(\frac{q^2 L}{2\pi\epsilon_0 m g}\right)^{1/3},$$

where x is the separation between the balls. (b) If $L = 120$ cm, $m = 10$ g, and $x = 5.0$ cm, what is q?

22-20 at equilibrium the free body diagram of particle (1) is given in the figure.



$$T_y = T\cos\theta = mg \quad ①$$

$$T_x = T\sin\theta = k\frac{qq}{x^2} \quad ②$$

$$\frac{②}{①} \Rightarrow \tan\theta = \frac{kq^2/x^2}{mg} = \frac{kq^2}{mgx^2} \quad ③$$

using $\tan\theta \approx \sin\theta \approx \frac{x/2}{L}$ in ③

(a) $$x^3 = \left(\frac{2kq^2L}{mg}\right) \Rightarrow x = \left(\frac{2kq^2L}{mg}\right)^{\frac{1}{3}}$$

(b) $$q = \left(\frac{mgx^3}{2kL}\right)^{\frac{1}{2}} = \left(\frac{10\times10^{-3}\times9.8\times(5\times10^{-2})^3}{2\times9\times10^9\times1.2}\right)^{\frac{1}{2}}$$

$$= (5.67\times10^{-16})^{\frac{1}{2}} = \underline{2.4\times10^{-8}\,C}$$