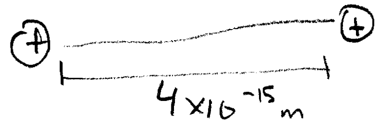
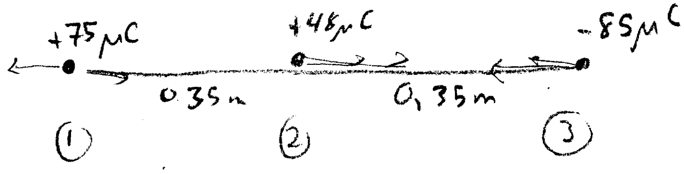
21-4



$Q_1 = Q_2 = 1.6 \times 10^{-19} C$ $\qquad k = 8.99 \times 10^9 N \cdot m^2/C^2$

$$F = k \frac{Q_1 Q_2}{r^2} = \frac{(8.99\times10^9 N\cdot m^2/C^2)(1.6\times10^{-19}C)^2}{(4\times10^{-15}m)^2} = \boxed{14.384\ N}$$

21-12

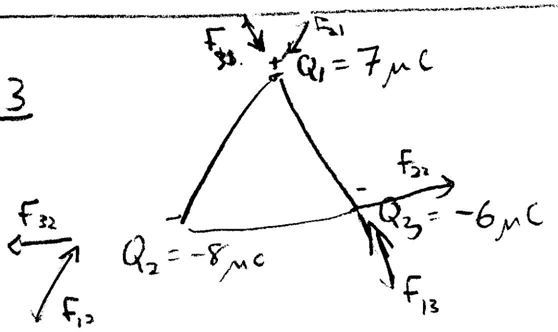


force on ①
$$F_{①} = k(75\mu C)\left(\frac{48\mu C}{(0.35m)^2} - \frac{85\mu C}{(0.70m)^2}\right) = \boxed{147\ N \text{ (to the left)}}$$
↑ force fr ② $\qquad$ ↑ force from ③

force on ②
$$F_{②} = (9\times10^9 N m^2/c^2)(48\mu C)\left(\frac{75\mu C}{(0.35)^2} + \frac{85\mu C}{(0.35)^2}\right)$$
$$= \boxed{564\ N \text{ to the right}}$$

force on ③
$$F_{③} = (85\mu C)(9\times10^9 \tfrac{Nm^2}{C^2})\left(\frac{75\mu C}{(0.7m)^2} + \frac{48\mu C}{(0.35m)^2}\right)$$
$$\boxed{F = 417 N \text{ (left)}}$$

21-13

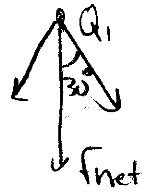


all angles are 60°

Magnitudes: $F_{12} = F_{21} = \frac{kQ_1Q_2}{(1.2m)^2} = k\frac{56(\mu C)^2}{1.44m^2}$ $\qquad F_{23} = F_{32} = \frac{kQ_2Q_3}{(1.2m)^2} = k\frac{48(\mu C)^2}{1.44m^2}$

$$F_{13} = F_{31} = \frac{kQ_1Q_3}{1.2m^2} = \frac{k\,42(\mu C)^2}{1.44m^2}$$

force on Q_1:

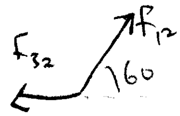


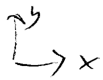
$$\vec{F}_{net} = \left(F_{21}\cos 30 + F_{31}\cos 30\right) \text{ down}$$

$$= \frac{\cos 30\, k}{1.44\,m^2}\left(56 + 42\right)(\mu C)^2$$

$$= 0.53 \text{ N down}$$

force on Q_2





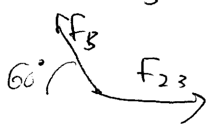
(choose coordinate system)

in x direction $\quad F_x = -F_{32} + F_{12}\cos 60$

y direction: $\quad F_y = F_{12}\sin 60$

$$F_{net} = \sqrt{F_x^2 + F_y^2} = \sqrt{(F_{12}\cos 60 - F_{32})^2 + (F_{12}\sin 60)^2} = 0.33\text{ N}$$

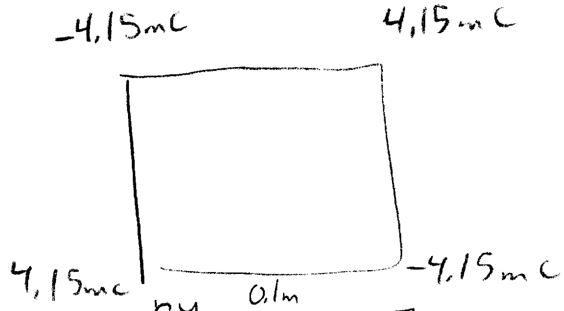
force on Q_3:

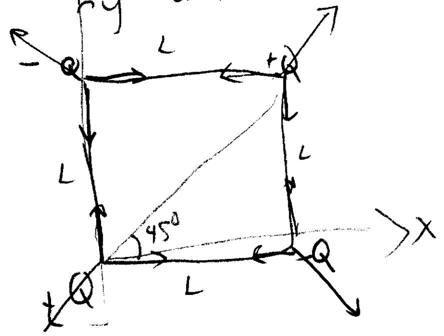


$$F_{net} = \sqrt{(F_{23} - F_{13}\cos\theta)^2 + (F_{13}\sin\theta)^2}$$

$$= 0.28 \text{ N}$$

21-16





It is clear that the net force on each charge will be equal. What is it?

define x, y axis shown

Consider bottom left charge

$$\vec{F}_{net} = \frac{kQ^2}{L^2}\hat{x} + \frac{kQ^2}{L^2}\hat{y} - \frac{kQ^2}{\left(\sqrt{L^2+L^2}\right)^2}\left(\cos 45\,\hat{x} + \sin 45\,\hat{y}\right)$$

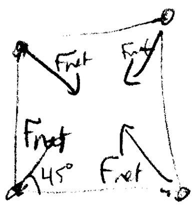
$$= \left(\frac{kQ^2}{L^2} - \frac{kQ^2}{2L^2}\frac{1}{\sqrt{2}}\right)\hat{x} + \left(\frac{kQ^2}{L^2} - \frac{kQ^2}{2L^2}\frac{1}{\sqrt{2}}\right)\hat{y}$$

$$= \frac{kQ^2}{L^2}\left(1 - \frac{1}{2\sqrt{2}}\right)(\hat{x} + \hat{y})$$

$$= \frac{(8.99\times10^9\,N\cdot m^2/C^2)(4.15\,mC)^2}{(0.1\,m)^2}\left(1 - \frac{1}{2\sqrt{2}}\right)(\hat{x} + \hat{y})$$

$$= 1.00\times10^7$$

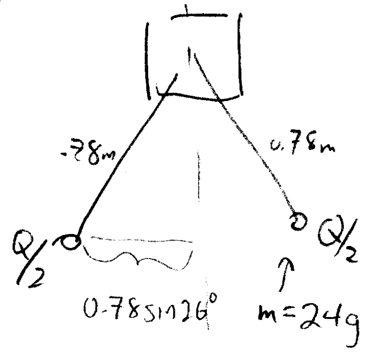
Since this value is positive, it is clear that the direction points in toward the center of the square (sketched below)

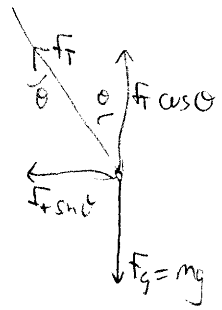


The angle is 45° from any side, as shown.

Solutions

21-80





$F_{net} = ma \quad a = 0$

so $F_{electric} = F_{gravitational}$

$F_{electric} = \dfrac{k\left(\frac{Q}{2}\right)^2}{\left[2(0.78\,m)(\sin 26°)\right]^2}$

$F_T \cos\theta = mg \rightarrow F_T = \dfrac{mg}{\cos\theta}$

$F_T \sin\theta = F_e$

$\dfrac{mg}{\cos\theta}\sin\theta = F_e = mg\tan\theta$

put together

$$\frac{k\left(\frac{Q}{2}\right)^2}{\left(2(0.78\,m)(\sin 26)\right)^2} = mg\tan 26°$$

$$Q = \left(\frac{(9.8\,m/s^2)(24g)(\tan 26)(16)(0.78\,m)^2(\sin 26)^2}{9\times10^9\,N\cdot m^2/c^2}\right)^{1/2}$$

$$\boxed{Q = 4.89\,\mu C}$$