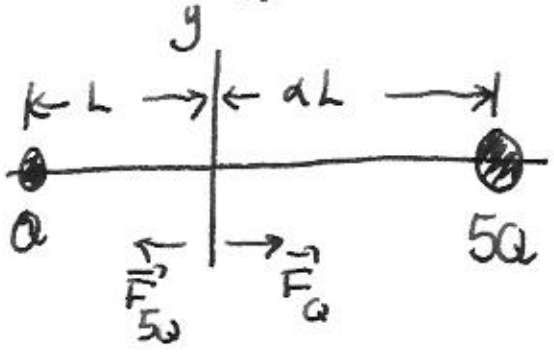
Physics 2B Spring 2013 Name_____

Dickson

Show all your work for full credit. No note cards, scratch papers or electronic devices are allowed. Each problem is weighted equally.

1. Two particles of charge Q and $5Q$ are located along the *x-axis* at $-L$ and $+\alpha L$ respectively as shown. When a third charge q is placed at the origin, it is found that the net force on it is zero. What is α?



system: charge q at the origin

$\vec{F}_{net} = m\vec{a}$

$\vec{F}_{net} = \vec{F}_{due\ to\ Q}$ and $\vec{F}_{due\ to\ 5Q} = 0$

$\vec{F}_Q + \vec{F}_{5Q} = 0$

$\hat{\imath}: \quad 0 = F_Q - F_{5Q}$

$F_Q = F_{5Q}$

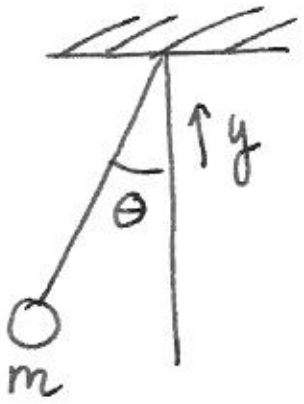
$$\frac{kQq}{L^2} = \frac{k5Qq}{(\alpha L)^2}$$

$$\left(\frac{\alpha^2 L^2}{L^2}\right) = \frac{5}{\alpha^2 L^2}\left(\alpha^2 L^2\right)$$

$$\alpha^2 = 5$$

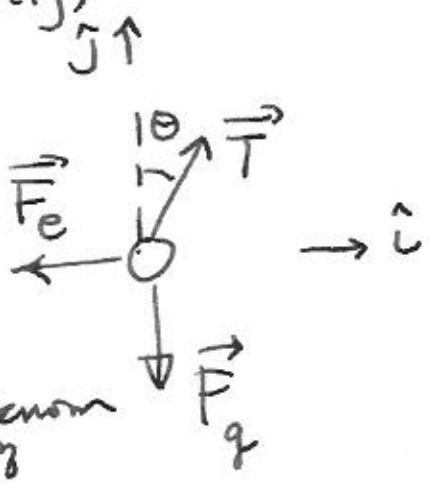
$$\boxed{\alpha = \sqrt{5}}$$

2. A small, plastic sphere of mass *m* is attached to a string as shown in the figure. There is an electric field of strength *E* directed along the *+x* direction. If the string makes an angle θ with the *y-axis*, what is the charge on the sphere? (DO not ignore gravity)



$\vec{E} = E_x \hat{i}$

$\vec{F} = q\vec{E}$



system: mass m with unknown charge q

$\vec{F}_{net} = m\vec{a}$

$\vec{T} + \vec{F}_e + \vec{F}_g = 0$

$\hat{j}$: $T\cos\theta - mg = 0$

$T\sin\theta - qE = 0$

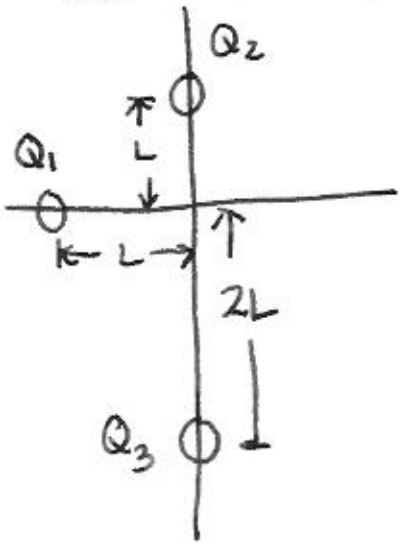
$T = \frac{mg}{\cos\theta}$

$mg\tan\theta = qE$

$q = \frac{mg\tan\theta}{E}$

it is a negative charge

3. Three point charges of Q_1, $Q_2 = 2Q_1$ and $Q_3 = 4Q_1$ are located along the x and y axes as shown. ~~How much work is required~~ what is the minimum work an external agent must do to assemble these charges from infinity? You may assume that $U(\infty)=0$



$$\Delta U_{TOTAL} = W_{ext}$$

$$\Delta U_{12} + \Delta U_{13} + \Delta U_{23} =$$

$$U_{12f} - \cancel{U_{12}(\infty)}^{0} + U_{13f} - \cancel{U_{13}(\infty)}^{0} +$$

$$U_{23f} - \cancel{U_{23}(\infty)}^{0} = W_{ext}$$

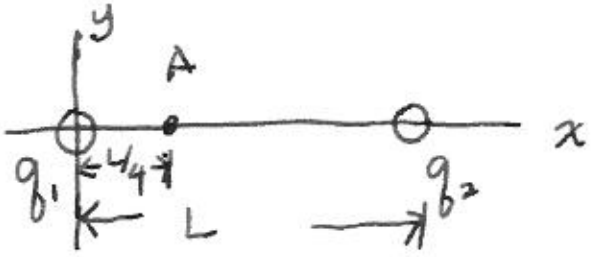
$$\frac{kQ_1Q_2}{\sqrt{2}L} + \frac{kQ_1Q_3}{\sqrt{L^2+(2L)^2}} + \frac{kQ_2Q_3}{3L} = W_{ext}$$

$$W_{ext} = \frac{kQ_1 2Q_1}{\sqrt{2}L} + \frac{kQ_1 4Q_1}{\sqrt{5}L} + \frac{k2Q_1 4Q_1}{3L}$$

$$W_{ext} = \frac{kQ_1^2}{L}\left(\frac{2\sqrt{2}}{2} + \frac{4\sqrt{5}}{5} + \frac{8}{3}\right)$$

$$W_{ext} = \frac{kQ_1^2}{L}\left(\frac{30\sqrt{2} + 24\sqrt{5} + 80}{30}\right)$$

4. Two point charges with charges q_1 and q_2 are separated by a distance L as shown. The electric potential is zero at point A, which is a distance $L/4$ from q_1. What is the ratio of q_1/q_2?



$$V_{\text{due to } q_1} + V_{\text{due to } q_2} = 0$$

$$\frac{k q_1}{L/4} + \frac{k q_2}{3L/4} = 0$$

$$\boxed{\frac{q_1}{q_2} = \frac{-1}{3}}$$

The negative sign indicates the charges are opposite.