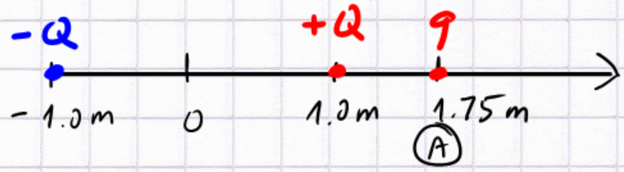
# Problem 17.29

Given an electric dipole, $Q = 3.3\,\mu C$ ; $+Q$ located at: $1.0m\,\hat{\imath}$, $-Q$ located at $-1.0\,m\,\hat{\imath}$. A probe charge $q$ is located at $1.75\,m\,\hat{\imath}$. The force on the probe is known to be $2.5N$ in strength, and directed towards the origin. What is $q$?




Solution:

Two Coulomb forces act on $q$:

NOTE: we use 1d forces with sign, i.e, vector info!

1) $F_{-Q\text{ on }q,x} = -K\dfrac{Qq}{(2.75m)^2}$

2) $F_{+Q\text{ on }q,x} = +K\dfrac{Qq}{(0.75m)^2}$

$q$ is with sign! ($q>0$ assumed)

Thus, $F_{net,x} = KQq\left(\dfrac{1}{0.75^2} - \dfrac{1}{2.75^2}\right)$ SI units

$0.75^2 \Rightarrow 1.78$, $2.75^2 \Rightarrow 0.132$

$F_{net,x} = q\;9.0\times10^9 \times 3.3\times10^{-6}\,(1.65)$ SI

$F_{net,x} = q \times 48.9 \times 10^3$ SI

force is 2.5 N towards the origin, i.e., to the left!

$-2.5 = q \times 48.9\times10^3$ $\therefore\; q = \dfrac{2.5}{48.9}\times10^{-3}\,C$

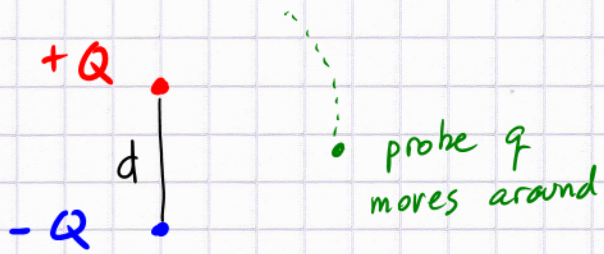
$q = -51.1\,\mu C \rightarrow -51.0\,\mu C$ (2 significant digits)

Q: Why is the sign of the charge negative?

A: to obtain a force to the left, the dominating contribution comes from the close-by charge (+Q), it has to be an attraction $\therefore q<0$.

# Electric Field

Quite often we have a fixed configuration of charges (such as a dipole, $\pm Q$ separated by some distance $d$ with known orientation). We are interested in how a probe charge $q$ is affected by this configuration. The probe charge $q$ can be moved to different locations. Perhaps it moves according to Newton's $2^{nd}$ law from place to place, while the charge configuration (dipole, etc.) remains fixed.




we need to know

$$\vec{F}_{+Q \text{ on } q} + \vec{F}_{-Q \text{ on } q} = \vec{F}_{\text{net on } q}$$

in many places

Define $\vec{E} = \dfrac{\vec{F}_{\text{net on } q}}{q}$ as the electric field

created by the charge configuration (e.g. dipole $\pm Q$)

$\vec{E} = \vec{E}(x,y)$ $\quad$ $(x,y)$ = location of the probe $q$

$\rightarrow$ could be $(x,y,z)$ in $\mathbb{R}^3$

In gravity at the earths surface:

$\vec{g}$ plays the role of (simplified) gravitational field

Weight $\vec{F} = m\vec{g}$ $\quad$ in analogy: $\vec{F}_{el} = q\vec{E}$ $\quad$ $\vec{E}(x,y,z)$ is to be calculated