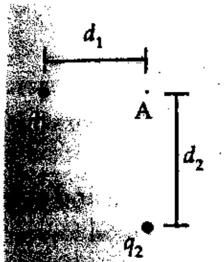


Two point charges, $q_1 = 3.00\ \mu C$ and $q_2 = 2.00\ \mu C$, are attached to the floor as drawn. Here, "μC" stands for microcoulombs.

Point A is located $d_1 = 1.00 \times 10^{-3}$ meters to the right of q_1, and $d_2 = 1.50 \times 10^{-3}$ m above q_2.

Point A is not a charge; it's just a spot on the floor.

(a) Suppose we place a particle of charge $Q = 0.010\ \mu C$ at point A. What is the magnitude of the electric force felt by Q?

(b) In what direction does that force push Q? Express your answer as an angle above the horizontal.

(c) Where could we place Q so that it would feel no electric force? Be as specific as possible, but use your intuition to get started. How far from q_1 should we put Q? Set up, but do not solve, the relevant equation or equations (unless you want algebra practice).

Key is to use <u>superposition</u>; force on Q due to each charge is independent of the others

$$\vec{F}_{Q,tot} = \vec{F}_{Q,1} + \vec{F}_{Q,2} \; ; \quad \vec{F}_{Q,1} = \frac{kQq_1}{d_1^2}\hat{i} = \frac{(9\times10^9)(0.01\times10^{-6})(2\times10^{-6})}{(10^{-3})^2}\hat{i}$$

$$= 270\ N\ \hat{i}$$

$$\vec{F}_{Q,2} = \frac{kQq_2}{d_2^2}\hat{j} = \frac{(9\times10^9)(0.01\times10^{-6})(2\times10^{-6})}{(1.5\times10^{-3})^2}\hat{j}$$

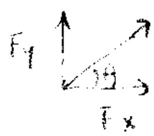
$$= 80\ N\ \hat{j}$$

$$\Rightarrow \boxed{\vec{F}_{Q,tot} = 270N\,\hat{i} + 80N\,\hat{j}}$$

a) Magnitude of this force

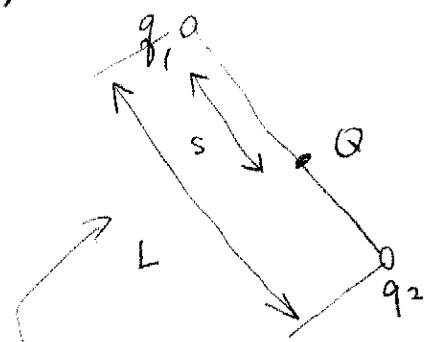
$$|\vec{F}_{Q,tot}| = \sqrt{270^2 + 80^2} = \underline{282\,N}$$

b) Direction, in terms of an angle:



$$\tan\theta = \frac{F_y}{F_x} = \frac{80}{270} \Rightarrow \boxed{\theta = 16.5^\circ}$$

c)



Intuition says:
no net force if balanced on line between the two charges

Closer to q_1 or to q_2?

q_1 pushes harder than q_2, so it should be closer to q_2

Balance point is at distance s from q_1

Want point where: $F_{Q,1} = F_{Q,2}$

$$\frac{kQq_1}{s^2} = \frac{kQq_2}{(L-s)^2}$$

$$L = \sqrt{d_1^2 + d_2^2}$$
$$= \sqrt{0.001^2 + 0.0015^2}$$
$$= 1.8 \times 10^{-3}\ m$$

solve for s

$$\left(\frac{L-s}{s}\right)^2 = \frac{q_2}{q_1}$$

At this point, it's just algebra..

I'll solve: $\frac{L-s}{s} = \sqrt{\frac{q_2}{q_1}}$

$$L = s\left(1 + \sqrt{\frac{q_2}{q_1}}\right)$$

$$S = \frac{L}{1 + \sqrt{q_2/q_1}} = \underline{\underline{9.9 \times 10^{-4}\ m}}$$

$= 0.55\ L$ → more than halfway to q_2, as expected.