Two identical spheres, attached to silk threads, have a distance between them of 0.5 m. The spheres are charged with different values of charge, q1 and q2. The spheres separate, each making an angle of 20° with the vertical.

(a) Draw a free body diagram, label all forces.

(b) Determine the magnitude of the electrostatic force acting on each sphere and determine the tension in each thread.

Resolve the forces into x and y components:

\[ T_x = T \cos 20° \]
\[ T_y = T \sin 20° \]
\[ F_x = T \sin 20° \]
\[ F_y = T \cos 20° \]

Solve for T:

\[ T = \frac{q_1 q_2 k}{r^2} \]
\[ T = \frac{(0.0825) \times (0.0825) \times 9 \times 10^9}{(0.3)^2} \]
\[ T = 0.8824 \]

Solve for the secondary force Fe:

\[ F_e = \frac{kq_1 q_2}{r^2} \]
\[ F_e = \frac{(9 \times 10^9)(0.0825)(0.0825)}{(0.3)^2} \]
\[ F_e = 0.342 \]

This Fe also must be:

\[ Fe = k \cdot \frac{q_1^2}{r^2} \]
\[ \theta = 20° \]
\[ r = 0.25 m \]
\[ \cos \theta = \frac{1}{2} \]

Let's find the value for q1 q2:

\[ q_1 = \frac{F_e r^2}{k} \]
\[ q_1 = \frac{(0.342)(0.25)^2}{9 \times 10^9} \]
\[ q_1 = 0.0348 \]
\[ q_2 = 0.0348 \]

(c) The charge are at same sign since they are repelling - part...

magnitude to be determined later.
(a) A small wind vane is used to connect spheres so new Q, k, F. We have:

\[ \theta = \theta_w, \quad B = B_s = 30^\circ \]

Determine \( \theta \) and \( B \) original.

In some electric part (b), apply but

\[ \text{values change: } \quad F_e = T \sin 30^\circ \quad \text{and } \quad mg = T \cos 30^\circ \]

Substitute for T: \( T = \frac{F_e}{\sin 30^\circ} \quad \text{and } \quad T = \frac{mg}{\cos 30^\circ} \)

Set equal to \( F_e = mg \): \( \Rightarrow \quad F_e = mg \sin 30^\circ \div \text{mag} \sin 30^\circ \)

\[ \left( \frac{F_e}{g} \right) = \frac{(8.00 \times 10^{-3} \text{ N})(9.81 \text{ m/s}^2)(0.587735)}{0.0453 \text{ N}} \]

This must equal the centripetal relation \( F_e = kQ^2 \)

where \( Q = \frac{r_v + \tau}{2} \) and the new \( r_v \)

\[ F_e \]

\[ \text{by } \tau = 2L \sin 30^\circ = 2L(\sin 30^\circ) = L = 0.500 \text{ m} \]

\[ \text{so, } \frac{F_e}{k} = \frac{kQ^2}{L} = \frac{k}{L} \text{ and } \frac{Q^2}{L} = \frac{1.12 \times 10^{-6} \text{ C}^2}{(9 \times 10^{-3} \text{ C})^2} = 9.2 \times 10^{-4} \]

\[ Q = \sqrt{9.2 \times 10^{-4}} = 0.0958 \text{ C} \]

\[ \text{Thus, } \quad Q^2 = (2.4 \times 10^{-3} \text{ C})^2 = 6 \times 10^{-6} \text{ C}^2 \]

\[ \text{Substitute into second relation: } \quad \frac{Q^2}{2} = \frac{1.70 \times 10^{-12} \text{ C}^2}{2} = \frac{4.2 \times 10^{-12} \text{ C}^2}{2} \]

This is a quadratic equation for \( \theta \).

Whole solution is \( \theta \) given by \( -1.8 \sqrt{2} = -1.8 \sqrt{0.12} \)

\[ \theta = 2.4 \times 10^{-3} \text{ C} - Q, \quad Q = 1.8 \times 10^{-7} \text{ C} \]

\[ \text{Thus, } \quad Q = 1.8 \times 10^{-7} \text{ C} \]