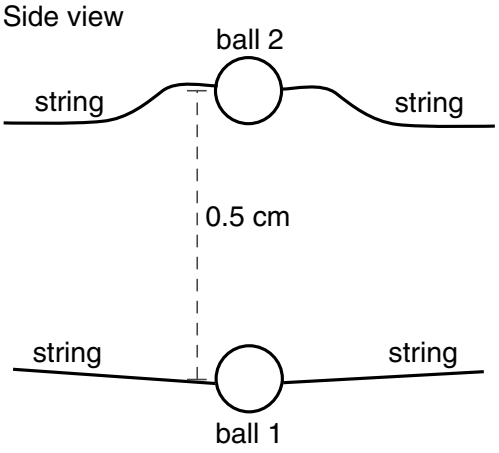
Problems: Finding electric force and electric charge

In your group, work these 3 problems on electric force and charge *on a whiteboard*.
You should finish these 3 problems in about 40 minutes, to leave time for the experiment.
These problems will give you some hints on how to design an experiment later.

(1) At location A there is an electric field $\vec{E} = \langle 5\times10^{4}, 0, 0 \rangle$ N/C. A tiny plastic ball, which has been rubbed all over with wool and has acquired a charge distributed uniformly over its surface, is placed at location A. The ball experiences an electric force of $\vec{F} = \langle -2\times10^{-6}, 0, 0 \rangle$ N. **What is the amount of charge on the ball?**

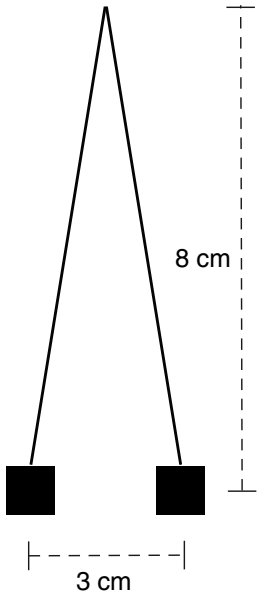
(2) Two small plastic balls, each of mass 2 g, are rubbed all over with wool, and both acquire the same amount of charge. Attached to each ball are four insulating nylon strings (only two strings are shown in the diagram; the other two are perpendicular to the page). When one ball is held above the other as shown, the top ball "floats" about half a centimeter above the other ball, and the strings attached to it become slack.



2.a) **Make a "freebody" diagram**, which shows *all* the forces acting on the upper ball. **Label** each arrow that represents a force.
2.b) **What is the approximate amount of charge on each ball?**
2.c) Can you determine the sign of the charge, or only the absolute value?

CHECKPOINT: Discuss your analyses with a neighboring group.

(3) Two small hollow glass cubes, of mass 1.4 g, are each rubbed with silk, and each cube acquires approximately the same amount of positive charge. The cubes hang motionless from strings, as shown in the diagram. ***Do each of the following steps:***



3.a) **Make a "freebody" diagram** showing all the forces acting on the left hand cube. **Label** each arrow that represents a force. Remember that a string can exert a force only along its length, as tension in the string.
3.b) Since the momentum of the left cube is not changing, **what do you know about the net force on the cube**? Check your diagram to make sure it is correct. (What is the sum of the forces shown in your diagram?)
3.c) **Look at the diagram** and calculate $\vec{r}$, a vector pointing from the left cube to the top of the left string, and the corresponding unit vector $\hat{r}$ that points along the left string. $\hat{r}$ is the direction of the force that the string exerts. Express the left string force as a vector, as the product of the (unknown) magnitude of the force times the unit vector, $\vec{F} = |\vec{F}|\hat{r}$. Or alternatively you can use trig to find the x and y components of the left string force, which is equivalent.
3.d) **Write equations** for the x component of the *net* force on the left cube, and the y component of the *net* force on the left cube.
3.e) At this point you should have two equations in two unknowns. Solve your equations to **find the approximate amount of charge** on each cube.
3.f) If you treated the cube as a point charge, **were you making an approximation**, or was this exactly correct?

CHECKPOINT: Discuss your analyses with a neighboring group.