Phy 251 Lab 01B-Q
(New for Spring 2014)

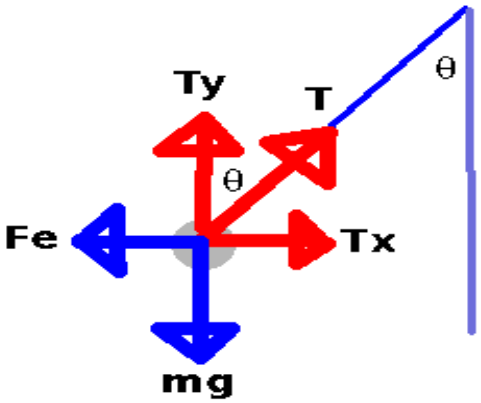
A fairly simple method for measurement of charge

You will measure charge in a very simple way. Cut two pieces of aluminum foil each about 1 cm on a side. Also you will need a piece of thread which is about 15-30 cm long. Form balls out of the aluminum foil with the string inside the foil ball. One ball is on one end of the string, the other ball is on the other end of the string. After you make this, weight it and record the weight. It is somewhat important that the foil squares be the same weight (or fairly close).

With a protractor and a dissecting pin through the central hole, hang the ball-string construction from the dissecting pin. The balls should be touching each other at this point and the angle on the protractor ought to be 90^0.

Now, charge the balls and let them separate. Record the total angle, which I call 2Θ, between the two balls. Using the analysis below, calculate the total charge on each ball.

The string has a tension T, This tension comes from gravitational interaction and also electrostatic interaction. On a particular ball, from Newton's laws we have:



$$\Sigma\vec{F}=\vec{0}$$
$$y: T_y - mg = 0$$
$$X: T_x - F_e = 0$$
$$T_y = T\cos(\theta) \Rightarrow T = \frac{mg}{\cos(\theta)}$$
$$F_e = T_x = T\sin(\theta) = \frac{mg\sin(\theta)}{\cos(\theta)}$$
$$\Rightarrow F_e = mg\tan(\theta) = \frac{kq^2}{4L^2\sin^2(\theta)}$$
$$\Rightarrow q = \pm 2L\sin(\theta)\sqrt{\frac{mg\tan(\theta)}{k}}$$

So, by measurement of 2Θ, L, mg and by knowing Coulomb's constant ($k=8.990\text{x}10^9$ Nm^2/C^2), a measurement of charge is possible. **Complete this calculation manually** (with correct units, verifying to yourself that the final units are coulombs; use μC in the final result: $1\mu C = 1\text{x}10^{-6}$ C). I have, though, included a helper to let you check your calculations. Note that the mass here is ½ of the total mass you measured. The angle Θ is ½ of the total angle between the strings (which you measure as 2Θ), L is the total length of the distance between the balls (about 0.20 m) in m and note the the distance between the two balls is $r = 2L\sin(\theta)$, and assume m to be ½ of the total weight of the string-ball construction in kg. Also, of course, $g = 9.8$ m/s^2.