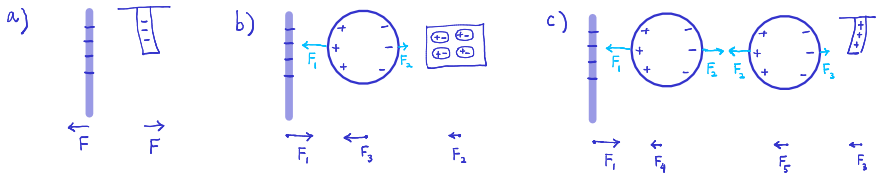
Physics Lab 206 — Feb 2016
Quiz #1 — Electrostatics I, II

Name:

1) Francis Hauksbee charges a rod using a piece of fur. The rod is negatively charged. An ordered tuple {first object, second object, third object, ...} means we put these objects in this specific order. You can find an example on the board. In each of the following cases, draw a schematic figure, show the distribution of the charges qualitatively, and draw the net force on each object using an arrow. Remember that the length of this arrow would represent the magnitude of the force.

a) {rod, negatively charged tape}. **[2 pts]**
b) {rod, neutral copper sphere, piece of paper}. **[3 pts]**
c) {rod, neutral sphere, neutral sphere, positively charged tape}. **[3 pts]**



Above we've neglected the interaction between the non-neighbor objects.

2) John Townsend in his free time does an experiment similar to the one we did in Electrostatics II. The humidity is low. After charging both spheres, by touching them with a charged rod, he reads $m = 0.34$ gr on the scale for the electrostatic force. He measures the distance between the spheres to be $r = 12.5$ cm. We call the charges on the spheres Q_1 and Q_2.

a) Write an equation and find Q_1Q_2. **[1 pts]**
b) He contacts the spheres together for a moment and puts them back at the same distance r. We call the charges on the spheres q_1 and q_2. Now he measures $m = 0.51$ gr on the scale for the electrostatic force. Find q_1. *Hint: First explain why $q_1 = q_2$.* **[2 pts]**
c) Now if he discharges one of the spheres to a capacitor, $C = 4.7\ \mu$F, which is connected in parallel to a voltmeter, what would be the reading on the voltmeter? **[1 pts]**
d) Use parts 'a' and 'b' to find Q_1 and Q_2. *Hint: Write the conservation of charge for part 'b'. Now you have two equations and two unknowns.* **[2 pts]**

a) $F_1 = k\frac{Q_1Q_2}{r^2} = 0.34 \times 10^{-3} \times 9.8\ N \rightarrow Q_1Q_2 = 5.8 \times 10^{-15}\ C^2$.

b) $q_1 = q_2$ because the spheres have the same size. $F_2 = k\frac{q_1q_2}{r^2} = k\frac{q_1^2}{r^2} = 0.51 \times 10^{-3} \times 9.8\ N$

$\rightarrow q_1^2 = 8.7 \times 10^{-15}\ C^2 \rightarrow q_1 = q_2 = -9.3 \times 10^{-8}\ C$. (negative root, the rod was negative)

c) $q_1 = CV \rightarrow V = \frac{q_1}{C} = \frac{-93\ nC}{4.7\ \mu F} = -19.8\ mV$.

d) (i) $Q_1Q_2 = 5.8 \times 10^{-15}\ C^2$

(ii) $Q_1 + Q_2 = q_1 + q_2 = -186\ nC$ (charge is conserved)

$\rightarrow Q_1 - Q_2 = \pm\sqrt{(Q_1+Q_2)^2 - 4Q_1Q_2} = \pm 107\ nC$

$Q_1, Q_2 = -147\ nC, -39\ nC$.

Here, we won't know which sphere had more charge.