Rules of conductors in static equilibrium
1. $E = \emptyset$ everywhere inside
2. Charge is on the surfaces of the conductor
3. Charge tends to accumulate at points
4. potential is constant inside

Name: KEY

Electrostatics Recitations Part 1

2011B2. (15 points)

An isolated, solid copper sphere of radius $R_1 = 0.12$ m has a positive charge (q) of 6.4×10^{-9} C.

(a)

i. Calculate the electric potential at a point 0.10 m from the center of the sphere.

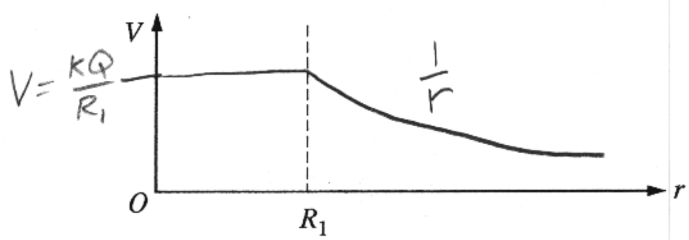
$$V = \frac{kQ}{r} = \frac{kq}{R_1} = 480\text{V}$$

ii. Calculate the electric potential at a point 0.24 m (R_2) from the center of the sphere.

$$V = \frac{kQ}{r} = \frac{kq}{R_2} = 240\text{V}$$

(b) On the axes below, sketch a graph of electric potential V versus radius r from the center of the sphere.

Label the value at $r = 0$ on the vertical axis.



(c)

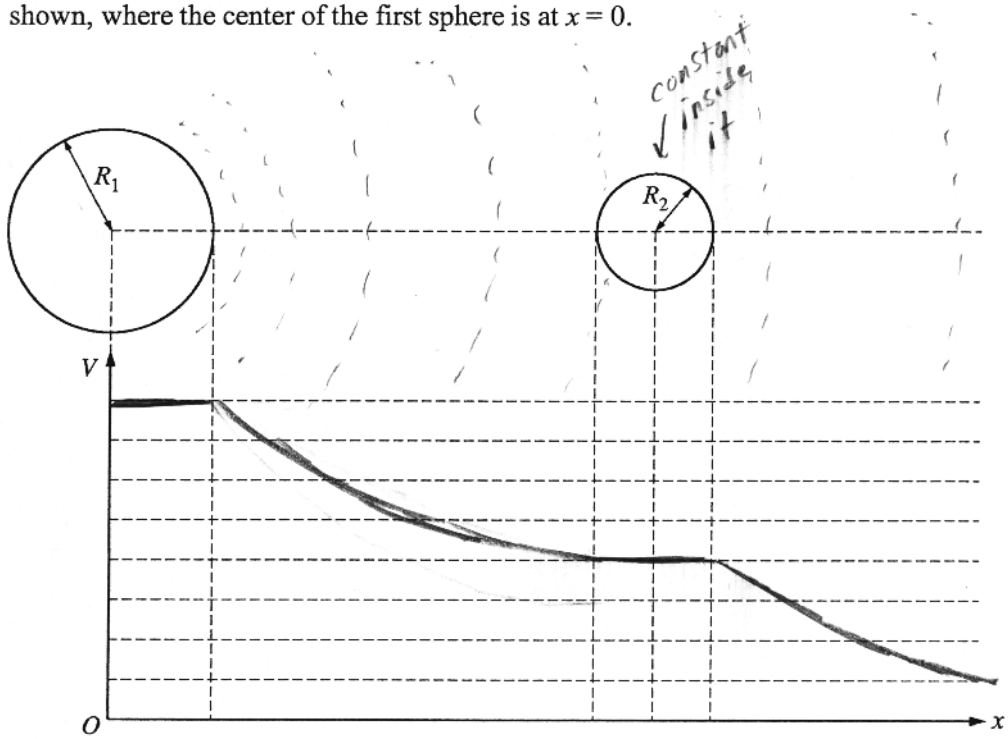
i. Determine the magnitude of the electric field at a point 0.10 m from the center of the sphere.

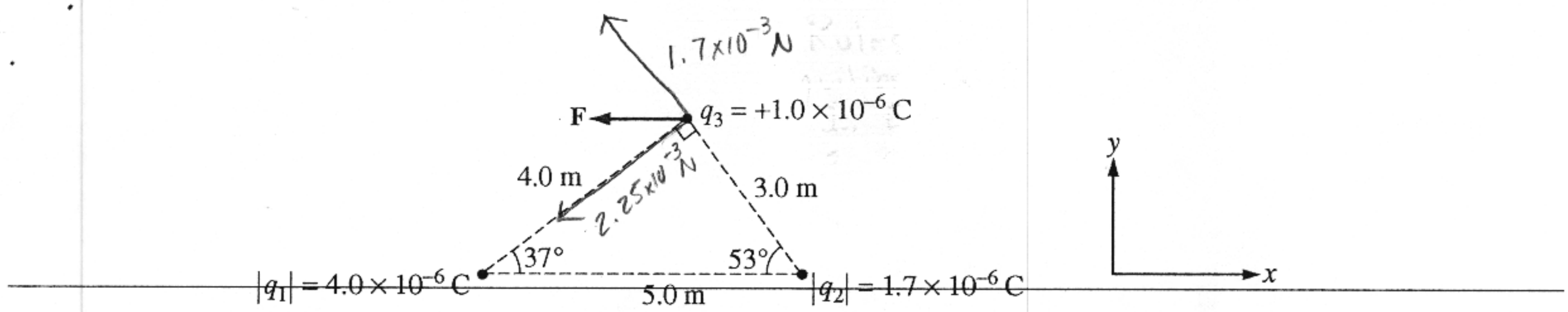
$E = \emptyset$ There is no E-field inside a conductor in static equilibrium.

ii. Determine the magnitude of the electric field at a point 0.24 m from the center of the sphere.

$$E = \frac{kQ}{r^2} = 1{,}000 \text{ N/C}$$

(d) A second copper sphere of radius R_2 that is uncharged is placed near the first sphere, as represented in the figure below. On the axes below, sketch a graph of electric potential V versus distance along the x-axis shown, where the center of the first sphere is at $x = 0$.





3. (10 points)

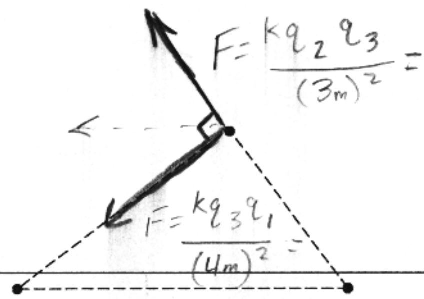
Three particles are fixed in place in a horizontal plane, as shown in the figure above. Particle 3 at the top of the triangle has charge q_3 of $+1.0 \times 10^{-6}$ C, and the electrostatic force **F** on it due to the charge on the two other particles is measured to be entirely in the negative *x*-direction. The magnitude of the charge q_1 on particle 1 is known to be 4.0×10^{-6} C, and the magnitude of the charge q_2 on particle 2 is known to be 1.7×10^{-6} C, but their signs are not known.

(a) Determine the signs of the charges q_1 and q_2 and indicate the correct signs below.

q_1 _✓_ Negative q_2 ____ Negative

____ Positive   _✓_ Positive

(b) On the diagram below, draw and label arrows to indicate the direction of the force F_1 exerted by particle 1 on particle 3 and the force F_2 exerted by particle 2 on particle 3.



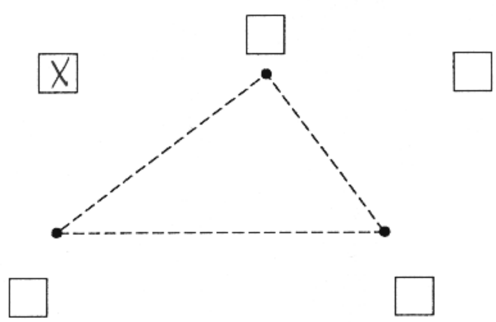
(c) Calculate the magnitude of **F**, the electrostatic force on particle 3.

$$\Sigma F = \sqrt{(F_{q_2 q_3})^2 + (F_{q_3 q_1})^2} = \boxed{2.82 \times 10^{-3}\ N}$$

(d) Calculate the magnitude of the electric field at the position of particle 3 due to the other two particles.

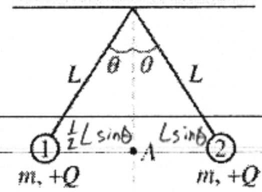
$$E = \frac{F_E}{q_3} = \boxed{2{,}820\ N/C}$$

(e) On the figure below, draw a small x in the box that is at a position where another positively charged particle could be fixed in place so that the electrostatic force on particle 3 is zero.



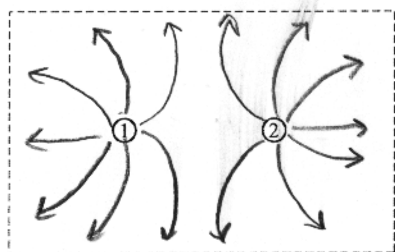
Justify your answer.

The particle will repel the q_3 charge and cancel the net force from q_1 and q_2



2. (10 points)
Two small objects, labeled 1 and 2 in the diagram above, are suspended in equilibrium from strings of length L. Each object has mass m and charge $+Q$. Assume that the strings have negligible mass and are insulating and electrically neutral. Express all algebraic answers in terms of m, L, Q, q, and fundamental constants.

(a) On the following diagram, sketch lines to illustrate a 2-dimensional view of the net electric field due to the two objects in the region enclosed by the dashed lines.

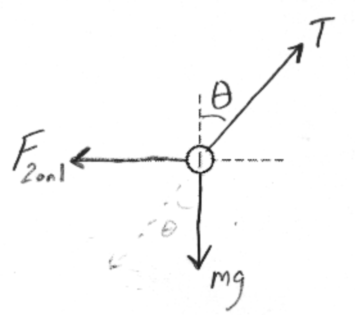


(b) Derive an expression for the electric potential at point A, shown in the diagram at the top of the page, which is midway between the charged objects.

$$V = \frac{kQ_1}{r_1} + \frac{kQ_2}{r_2} \qquad r = L\sin\theta \qquad V = k\sum_i \frac{q_i}{r_i}$$

$$\boxed{V = \frac{k2Q}{L\sin\theta}}$$

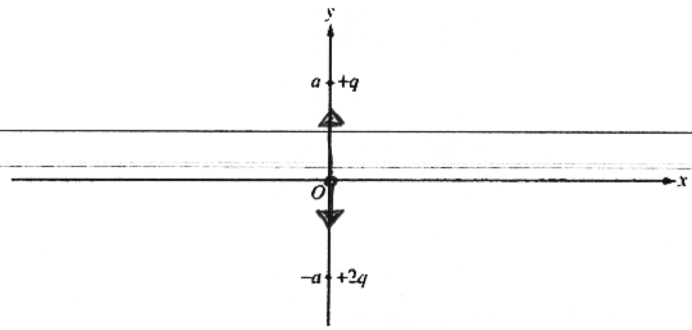
(c) On the following diagram of object 1, draw and label vectors to represent the forces on the object.



(d) Using the conditions of equilibrium, write—but do not solve—two equations that could, together, be solved for θ and the tension T in the left-hand string.

$$T\cos\theta = mg$$

$$T\sin\theta = F \qquad T\sin\theta = \frac{kQ^2}{(2L\sin\theta)^2} = \boxed{\frac{kQ^2}{4L^2\sin^2\theta}}$$



2005B3 (15 points)Two point charges are fixed on the y-axis at the locations shown in the figure above. A charge of $+q$ is located at $y = +a$ and a charge *of* $+2q$ is located at $y = -a$. Express your answers to parts (a) and (b) in terms of q, a, and fundamental constants.

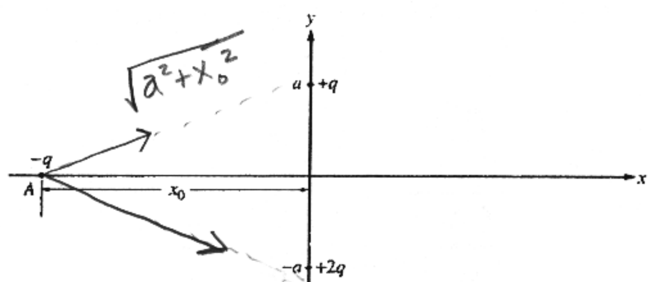
a. Determine the magnitude and direction of the electric field at the origin.

$$\Sigma E = E_1 + E_2 = -\frac{kq}{a^2} + \frac{k2q}{a^2} = \boxed{\frac{kq}{a^2}}$$ upward

b. Determine the electric potential at the origin.

$$\Sigma V = k\sum_i \frac{q_i}{r_i} = k\left(\frac{q}{a} + \frac{2q}{a}\right) = \boxed{k\frac{3q}{a}}$$

A third charge *of* $-q$ is first placed at an arbitrary point A ($x = -x_o$) on the x-axis as shown in the figure below.



c. Write expressions in terms of q, a, x_0, and fundamental constants for the magnitudes of the forces on the $-q$ charge at point A caused by each of the following.

i. The $+q$ charge

$$F = \frac{k(-q)q}{\left(\sqrt{a^2+x_o^2}\right)^2} = \boxed{\frac{k(-q^2)}{a^2+x_o^2}}$$

ii. The $+2q$ charge

$$F = \frac{k-q(2q)}{\left(\sqrt{a^2+x_o^2}\right)^2} = \boxed{\frac{k(-2q^2)}{a^2+x_o^2}}$$

d. The $-q$ charge can also be placed at other points on the x-axis. At each of the labeled points (A, B, and C) in the following diagram, draw a vector to represent the direction of the net force on the $-q$ charge due to the other two charges when it is at those points.