PROBLEM 1 – 10 points

You have three identical metal spheres that have different initial net charges. Sphere A has a net charge of +10*Q*; sphere B has a net charge of –6*Q*; and sphere C has a net charge of +14*Q*. You first touch sphere B to sphere A, and then separate them; you then touch sphere A to sphere C, and then separate them; and finally you touch sphere C to sphere B, and then separate them.

[2 points] (a) Assuming no charge is transferred to you, what is the total combined charge on the three spheres at the end of the process?

[2 points] (b) What is the charge on sphere A at the end of the process?

[2 points] (c) What is the charge on sphere B at the end of the process?

[2 points] (d) What is the charge on sphere C at the end of the process?

[2 points] (e) What if the spheres had been made from insulating material instead, with the same initial charges. Would any of the answers above definitely be the same after the same process of touching and separating described above?

[ ] all of the answers would still definitely be the same

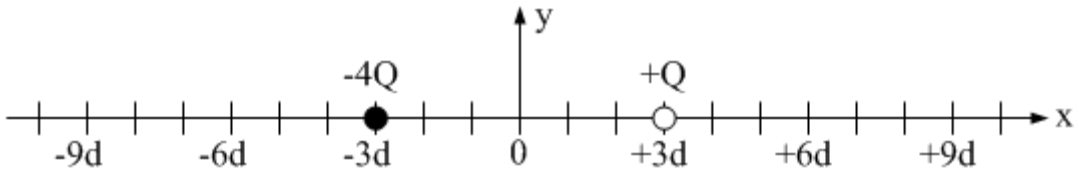
[ ] none of the answers have to be the same

[ ] the answer to part (a) would stay the same; the others could be different

[ ] the answer to part (a) could be different; the others have to stay the same

PROBLEM 2 – 10 points

Two charges are placed on the x-axis. The charge at x = -3d has a charge of –4Q, while the charge at +3d has a charge of +Q.



[2 points] (a) The net electric field due to the two charges is zero at at least one location on the x-axis near the two charges. In which region(s) is there such a point on the x-axis, where the net electric field is zero a finite distance from the charges? **Select all that apply**.

[ ] to the left of the –4Q charge

[ ] between the charges

[ ] to the right of the +Q charge

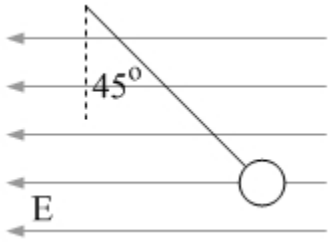
[5 points] (b) Determine the location of one such point on the x-axis near the charges where the net electric field is zero.

[3 points] (c) Are there any points near the charges, **but not on the x-axis**, where the net electric field due to the point charges is zero? Explain.

PROBLEM 3 – 15 points

A small ball with a weight of 10 N is hung from a string that is made of insulating material.

The ball and string is first placed in a region of space in which there is a uniform electric field with E = 2.0 x 10^4 N/C directed horizontally to the left. The ball has an unknown net charge. When the ball is in equilibrium the string is at a 45° angle, as shown.



[3 points] (a) Sketch a free-body diagram for the ball in this situation.

[3 points] (b) Can we neglect gravity in this situation? Briefly justify your answer.

[4 points] (c) What is the sign and magnitude of the net charge on the ball?

[5 points] (d) The string will break if its tension exceeds 25 N. The ball is now given a net charge of +1.0 x 10^{-3} C and placed in a region where you can introduce a uniform electric field in any direction you choose. The field is initially off, and the ball hangs vertically from the string, as shown. Assuming the magnitude of the electric field is changed gradually, what is the direction and magnitude of the **minimum** electric field necessary to cause the string to break?