TEAM ____________________________________ Schneider – Univ2 – Spring 2007

HONORS TEAMWORK 04 “Charges, charges, charges .. why the heck am I thinking about charges?” – 03/02/07

Author ______________________________ **Name ______________________________________**

Name _______________________________ **Name ______________________________________**

(It is strongly suggested that you try to adopt some of the roles indicated {such as Recorder, Taskmaster, Gatekeeper, Devil’s Advocate} – if roles are used, please indicate next to the names.)

Preparation – read over team roles and read through entire team project (silently, individually) – *5 minutes*

Problem – ***45*** *minutes [Papers turned in after 10:55 won’t be accepted.]* [Parts D, E and F are differ from the non-honors version.]

a) Lightly sketch the electric field curves for each of the charges shown below (the distance between them is **3 meters**). Then darkly sketch the combined **electric field** curve for that system (the net electric field … that is, "add" the two graphs). (Your graphs should show “rough features”, but don’t worry if the numerical answers we get later don’t quite match.)

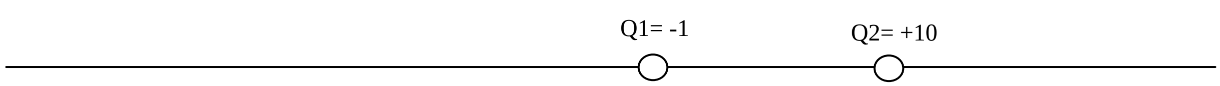
b) You should find a "crossing point" (where the net electric field is zero). Justify the crossing being where it is (that is, how would you argue that it is reasonable for it to be there … not "well, the graph says it" **– argue conceptually** that it should be there).

c) Show the steps to **calculate** the location of the zero Electric field point in the above system. First solve it with the charge variables (that is, don't plug in the numbers yet). Then plug in the numbers given for a numerical answer. Make sure you indicate where the origin in the system is! (For example, you could assume q1 is at the origin.)

d) Suppose we add a third charge on the axis, **Q3**? In between the two original charges, you should have found a local minimum or maximum (oops, I guess I gave something away there, huh?). I wonder if you can place a charge Q3 that is to the LEFT of Q1, or to the RIGHT of Q2 …. That would create at least one crossing point between Q1 and Q2. You don’t need to try to calculate a location, but you should discuss if it is possible, and if so, what qualities does Q3 have to have (sign, relative size, etc.). And, to make it interesting .. you **can’t try to place a charge closer than 3 meters** to the left of Q1 or to the right of Q2! [There might be several ways to “answer” this question … can Dr. Scott BE any more vague {there’s a little Chandler shout-out for you ..}.] Discuss/defend your results.

e) Go back to the original 2 charge system, can you come up with general “rules” to describe how a combined E-field graph might be different if you: 1) switched the signs of both charges or 2) swapped the locations of the existing charges ? {I’m looking for a simple way, in each case, to describe how the “new” pattern might be different from the old pattern.}

f) Using your rules from part E … with they work if you switch the sign of only one of the charges?



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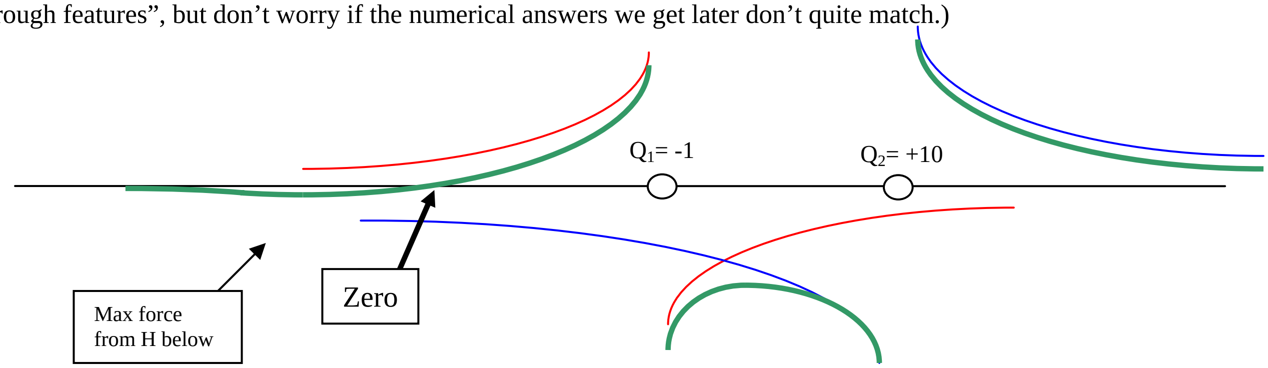

b) You should find a "crossing point" (where the net electric field is zero). **Justify** the crossing being where it is (that is, how would you argue that it is reasonable for it to be there … not "well, the graph says it" – **argue conceptually** that it should be there).

If we look far to the left .. the system looks positive (basically + 9) .. that would mean the net electric field should point to the **left** (the curve should be plotted under the axis) .. but as we get closer, the -1 C charge will dominate .. thus it should have a net electric field pointing **right** (plotted above the axis) - thus, there must be a crossing point to the left of the system (also notice that it is located **outside** the **weaker** of the two opposite signed charges).

c) Show the steps to **calculate** the location of the zero Electric field point in the above system. First solve it with the charge variables (that is, don't plug in the numbers yet). Then plug in the numbers given for a numerical answer. Make sure you indicate where the origin in the system is! (For example, you could assume q1 is at the origin.)

Set magnitudes equal to each other (use bigger charge as the origin of the variable r - zero should show up to the left of the left charge … this is not the <u>only</u> way to assign variables - *this is just the way I chose*!). Measuring x from q2 :

$$\frac{k|q_{small}|}{r_{small}^2} = \frac{k|q_{big}|}{r_{big}^2} \qquad \frac{q_{small}}{(x-d)^2} = \frac{q_{big}}{x^2} \qquad q_{small}x^2 = q_{big}(x-d)^2 \qquad (x-d)\sqrt{\frac{q_{big}}{q_{small}}} = x \qquad x = \left(\frac{\sqrt{q_{big}/q_{small}}}{\sqrt{q_{big}/q_{small}}-1}\right)d \qquad x = \frac{\sqrt{10}}{\sqrt{10}-1} = 4.39m$$

Thus, 1.39 m to the left of Q1 .. or 4.39 m to the left of Q2.

d) Suppose we add a third charge on the axis, **Q3**? In between the two original charges, you should have found a local minimum or maximum (oops, I guess I gave something away there, huh?). I wonder if you can place a charge Q3 that is to the LEFT of Q1, or to the RIGHT of Q2 …. That would create at least one crossing point between Q1 and Q2. You don't need to try to calculate a location, but you should discuss if it is possible, and if so, what qualities does Q3 have to have (sign, relative size, etc.). And, to make it interesting .. you **can't try to place a charge closer than 3 meters** to the left of Q1 or to the right of Q2! [There might be several ways to "answer" this question … can Dr. Scott BE any more vague {there's a little Chandler shout-out for you ..}.] Discuss/defend your results.

To make a crossing point (and it appears that you might create TWO by "definition") – you would need to "drag" the net field above the axis. We can't add a positive charge to the right of Q2, or a negative charge to the left of Q1 … that would just be like increasing the strengths of either of them. Thus, we'll have to do the opposite (and either should work) : add a negative charge to the right of Q2 or a positive charge to the left of Q1. The rule about "more than 3 meters" is just a distracter, in case you thought of "canceling" one of the existing charges .. but, that's essentially what we will have to do! If we put a huge negative charge to the right of Q2 – that would add a "second quadrant" hyperbola curve into the area between the two original charges. If this curve were large enough, then near the middle, we would have a large enough value above the axis to drag the net value above, and form two crossing points. Note – the net field MUST drop back down below the axis as it gets close to Q1 and Q2 because THEY RULE near them! The same reasoning would work with a huge + charge to the left of Q1.

e) Go back to the original 2 charge system, can you come up with general "rules" to describe how a combined E-field graph might be different if you: 1) switched the signs of both charges or 2) swapped the locations of the existing charges ? {I'm looking for a simple way, in each case, to describe how the "new" pattern might be different from the old pattern.}

If you switch the signs of both – flip the net curve vertically around the x axis.
If you switch locations – flip the net curve horizontally around a vertical line between the charges.

f) Using your rules from part E … with they work if you switch the sign of only one of the charges?

Nope – that would only flip the "progenitor" graph for that particular charge – no simple rule.

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University Physics 2 Team Project # 4 Spring 2007 03/02/07 HONORS Solution Key

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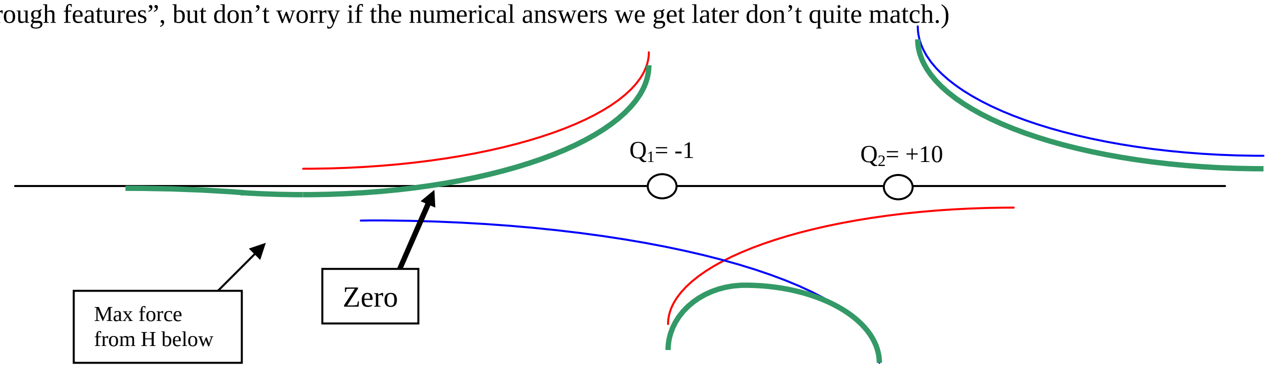

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