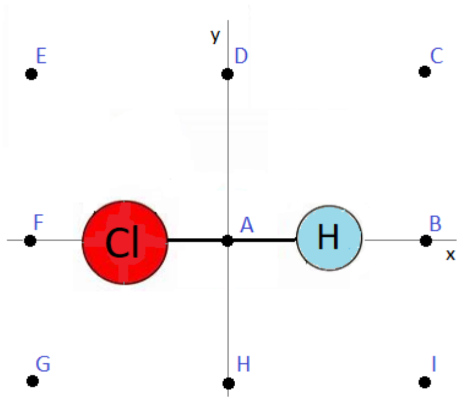
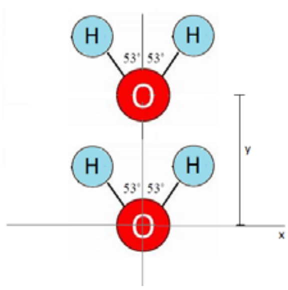
Homework 4: Electric Force due 4/30

Problem 1. Our HCl molecule is back! Recall the Cl atom has got a charge of -e, the H atom a charge of +e, and the bond length is 127pm. Suppose we alternately place a proton and electron at each of those coordinates. What force (magnitude and direction – specified as an angle from the +x axis) would the HCl molecule exert on it? Draw those two forces at each point. You may use the results of our calculations in previous assignments to expedite your work.



Problem 2. Let's take another look at our water molecule, recalling the effective charge of O is -0.70e, and the effective charge of H is +0.35e. This time we're going to place another water molecule, lined up along the same axis. The bottom water molecule will exert a force on the top water molecule. Calculating this force is somewhat annoying because there is a separate force on the top O and each of the top H's. And the net force on the water molecule would be the resultant of these three forces. To avoid that complexity, let's just consider the top O alone. You can use the results of calculations in a previous homework assignment to (vastly) expedite your work.



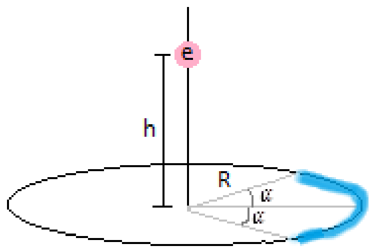
(a) Where is the force the bottom water molecule exerts on the top O zero?

(b) Where is it attractive?

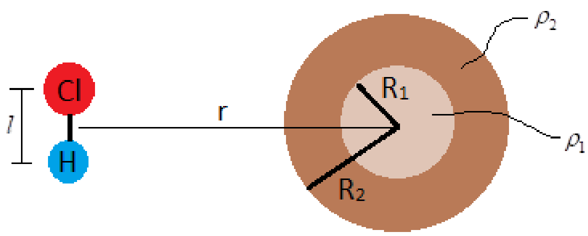
(c) Where is it repulsive?

(d) Is the top water molecule stable with respect to perturbations? That is to say, does the electric force on it act like a spring so that it will restore the top O to its equilibrium (F = 0) point if it is slightly displaced from the equilibrium point in either direction? Your previous answers will address this question.

Problem 3. Let's take another look at the charged R = 3m semi-ring from HW 1, where we smeared 7nC over the $\alpha = \pm 30°$ interval. Say we place an electron at the h = 6m point along the central axis. What would be the magnitude and direction of the force on it? Display it on the diagram. Might want to use previous HW results again.



Problem 4. Let's resurrect our 'typical cylinder shaped branch'. Remember say R_1 = 5cm, and R_2 = 10cm. And ρ_1 = 7pC/m^3, and ρ_2 = 3pC/m^3. Now let's say that we have an overall neutral molecule, like HCl outside the branch, a distance r = 5m away.

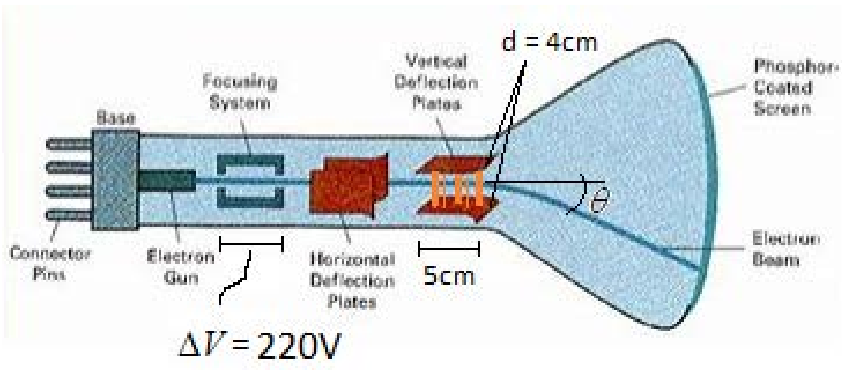


(a) What is the net force on this molecule at present? Don't calculate anything.

(b) Which way is the molecule going to rotate? And what orientation will it stabilize at? Draw it below por favor.

(c) *Now* what is the net force on the molecule? You might want to recall the results of calculations in previous homework assignments. Note this is one way the electric force can attract even overall neutral molecules, like when a charged comb attracts bits of neutral paper, or when neutral molecules attract each other into stable solid or liquid configurations. Should get an answer ~ 10^{-33}N.

Problem 5. Instead of doing physics I'm going to watch TV….or watch *the* TV, I mean the *inside* of the TV, specifically the *electrons* inside the TV. Huh. It seems those electrons are being accelerated by a 220V potential difference. They must be going really fast. And later, it seems they're being vertically deflected $\theta = 20°$ by those orange electric field line things running between the plates. Are electric fields really orange? Is that why oranges are so sour? I don't know. I don't know anything in this class. Hey did you know that the mass of an electron is 9.11×10^{-31}kg!? That sure is small.



(a) Gee, I bet I know which way those electric field lines are pointing.

(b) I can probably even calculate what the strength of that orange electric field is. Maybe not. But by golly I'm a Mustang, and I'm not going down without a fight! At least I remember from PHY 141 that the angle something is traveling at is $\theta = \tan^{-1}(v_y/v_x)$. If I'd forgotten that, I'd be screwed. Or worse. I wonder if gravity matters? Nah, I'll bet the electric field force is muuuuuuuch greater than the gravitational field force.

(c) I did it! Maybe. How could I even *create* such a field? I know! I'd hook up a battery to those two plates. The battery would charge the plates to its own potential difference, and then the charges would set up the field. But what potential difference would my battery have to have I wonder?