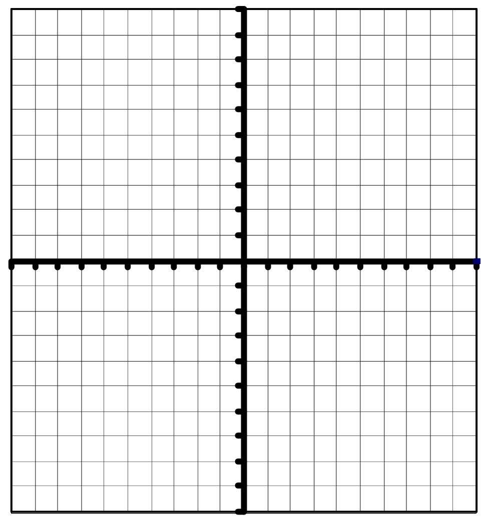
Names:____________________

Charged Particles and You

Background: Particles with electric charges, such as protons and electrons, create electric fields in the space around them. These electric fields interact with other charged particles, moving magnets and whatnot. Electrons and protons have the same electric charge on them, so that if you get an electron and a proton close enough, their charges essentially cancel each other out. Specifically, an electron and a proton together form a hydrogen atom with no electric charge.

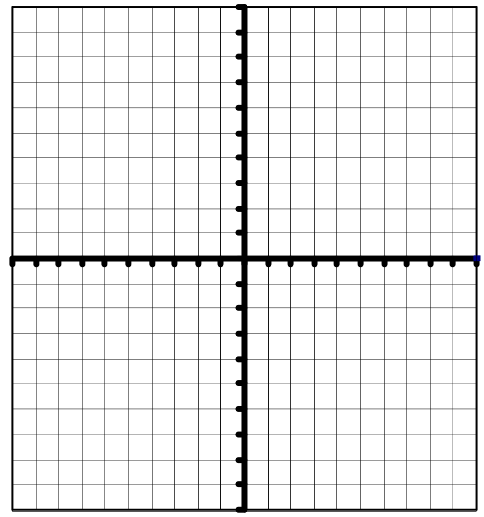
1. Imagine an electron in a long, thin tube (so that we only have one space dimension x). If we pick the correct units, an electron placed at the origin has an electric field given by $E_0(x) = -\frac{1}{x^2}$. Scaling your chart so that every block is ½ unit, graph this function. Your horizontal axis should tell you your position and the vertical axis should tell the electric field at that position. Can you think of a reason why this function has a vertical asymptote at the point where it does? Can you think of why the function has the horizontal asymptotes that it has?



2. Using concepts we learned in previous chapters, give a formula $E_d(x)$ for the electric field of an electron at $x = d$ (i.e. translated d units along the x-axis. This **doesn't** mean plug d in for x.) As a check, $E_d(d)$ should be undefined.

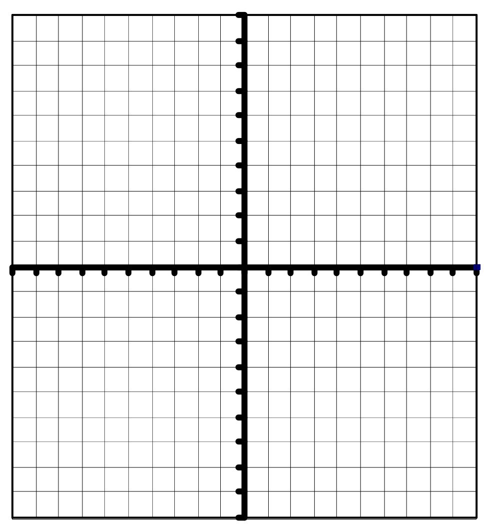
3. As stated a proton and an electron have opposite charges. So the electric charge of a proton P_d placed at $x = d$ is just the negative of that of an electron. I.e. $P_d(x) = -E_d(x)$. Write down the formula for $P_d(x)$.

4. Now let's consider the case where we have a proton at the point $x = 0$, and an electron at $x = d$. Using the equations you found above, graph the electric field of the proton on the graph, then graph the electric field of the electron on the same graph if d=3. Again, **don't plug x=0 or x=d in anywhere**.



5. In a situation like this, where you have two different electric fields, the total field at any point is the sum of the electric fields given by each particle. In this case, the electric field is $P_0(x) + E_d(x)$. Leaving d just as a letter, write down this equation and simplify it into the form of a rational function.

6. Graph the function you found in part 5 with d=3. Remember that the height of the graph at each x tells the strength of the field and whether it's positive or negative. Compare your answer to the one in problem 4. There should be a definite correlation. What does the zero of this function represent?



7. On the same graph, graph the function you found in part 5 with d=0. Is the result surprising? Why does the graph look like it does? (See the Background for a reference. Note that this is a case in nature of two infinities canceling each other out. Neat, huh?)