Homework 8 for September 10 2008
Due 8AM on September 12 2008
Physics 221 with Professor Jeff Terry

Average: 73%
StDev: 19%

1. We have a 1 dimensional isolated system. A charge of -2.50*10^{-6} C is at the origin while a charge of +6.00*10^{-6} C is 1.00m to the right (in the positive x direction). Identify a location where the electric field is zero. (Up to 1 extra point possible if you can name more than one.)

The E field is given by $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ with positive being defined as "away" from the source. In the region between the two charges we can already see that the total field can not be zero, for the field from each charge points in the same direction. In the regions to the right of the positive charge and to the left of the negative charge the fields will point in opposite directions, and since all we want to know is when the field will be zero we can forget about signs and look for when the magnitudes of the fields for each charge will be equal.

The r for the negative charge will be equal to x while the r for the positive charge will be x-1. Thus we have,

$$E = \frac{1}{4\pi\varepsilon_0}\frac{|q|}{r^2}$$

$$\frac{1}{4\pi\varepsilon_0}\frac{2.50*10^{-6}C}{(x)^2} = \frac{1}{4\pi\varepsilon_0}\frac{6.00*10^{-6}C}{(x-1)^2}$$

$$2.50*10^{-6}(x-1m)^2 = 6.00*10^{-6}(x)^2$$

$$2.50*10^{-6}(x^2+1m^2-2mx) = 6.00*10^{-6}(x)^2$$

$$0 = 3.50*10^{-6}(x)^2 + 5.00*10^{-6}mx - 2.50*10^{-6}m$$

$$x = 0.39m \;\&\; -1.82m$$

We end up with +0.39m and -1.82m (and remember that the convention is + means to the right of the negative charge). But remember, we already said that the region between the charges is not being considered because the fields point the same direction and can never add to zero. So **+0.39m is not** a **correct** answer.

There are two other places that the field can be zero – positive and negative infinity. This is because at these points the field from each source will be zero, so, of course, the vector sum will also be zero. If you

identify -1.82m as an answer you get 2 pts, you get ½ pt for each of positive and negative infinity if you identified them, and you lose a point if you identified +0.39m.

2. Imagine a proton travels through the 1 dimensional system from the left. What happens when it hits the point where the E field is zero? (No diagram necessary for this one, and it is worth 3 points.)

Basically all you needed to say is that the force on the proton is zero, or, equivalently, the acceleration of the proton is zero, or the velocity becomes constant (albeit momentarily). Anything like that will get you full credit.

3. The electrons in a particle beam each have a kinetic energy K. What are the magnitude and direction of the electric field that will stop these electrons in a distance d?

To determine the direction, we think about the behavior of an electron in an electric field. Specifically, an electron accelerates in the direction opposite of the field. So, **the direction of the E field should be in the same direction as the motion of the electron**. The magnitude is fairly straight forward.

$$W = F * D = QE * d$$
$$W - K = 0$$
$$K = Q_{e^-} E * d$$
$$E = \frac{K}{Q_{e^-} d}$$