Phyx 135-2, Quiz 1 (1 pm) **Name** ____

1) Suppose particle 1 with a charge of –80 μC is located at x = 0 on an x-axis, and particle 2 with a charge of +20 μC is located at x = 20 cm. Where would I have to place a third particle with a charge of +20 μC such that the total force on the third charge is zero?

Solution: We are looking for a spot where the electric field from particles 1 and 2 is zero, which means that the charge on the third particle does not matter. I just threw that in so as to cause confusion.

Charge 3 cannot be between charges 1 and 2, because in that region their electric fields are both in the same direction and cannot cancel. It cannot be in the region of $x < 0$ because charge 1 is greater than charge 2, so charge 2 (which is farther away) can never cancel charge 1 there.

Thus charge 3 is in the region $x > 20$ cm. One can quickly get the distance where F = 0 by recognizing that charge 1 is exactly four times the magnitude of charge 2, so charge 1 needs to be exactly twice as far from charge 3 as charge 2 is from charge 3 for cancellation to occur. This is true at x = 40 cm.

Alternatively, you can be more mathematical and set $kq_1 / x^2 + kq_2 / (x - 20)^2 = 0$, where "x" is the unknown distance of charge 3. (It is OK to use cm instead of meters because the units cancel out.) A little algebra yields $4(x - 20)^2 = x^2$, or $2(x - 20) = x$, or x = 40 cm.

2) Suppose that an electric dipole has charges +3e and –3e separated by 0.68 nm, and is oriented along the positive ***i*** (or x) axis with its negative charge to the left (positive charge to the right). Then an electric field with ***E*** = 4000 N/C ***i*** + 3000 N/C ***j*** is placed across the dipole.

a) At what new angle (relative to the x-axis) will the dipole try to point?

b) How much kinetic energy will the dipole gain or lose as it rotates to the angle in part (a)?

Solution: The dipole will try to rotate to lie along the electric field. The angle of the electric field is given by $\tan\theta = ¾$, or $\theta = 36.9°$

The dipole will gain rotational kinetic energy as it spins into its new position. We have:
$U = pE \cos\theta = (0.68\ \text{nm})(3e)(5000\ \text{N/C}) \cos(36.9°) = 1.3 \times 10^{-24}$ J as the magnitude of the initial potential energy of the dipole. When it is aligned with the field, $\cos\theta = 1$, so its energy in that state will be $(0.68\ \text{nm})(3e)(5000\ \text{N/C})(1) = 1.63 \times 10^{-24}$ J. The difference in potential will show up as kinetic energy, so $\Delta U = 1.63 \times 10^{-24}\ \text{J} - 1.3 \times 10^{-24}\ \text{J} = 0.33 \times 10^{-24}$ J.