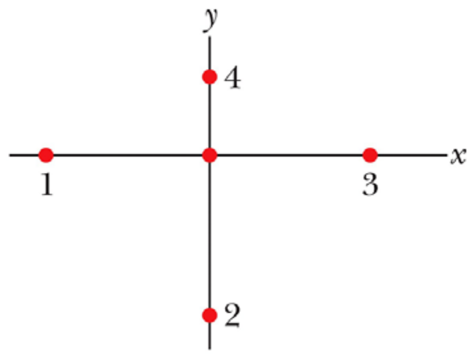
Phyx 135-2, Quiz #1 (10 am) **Name** ________________________________



1) Suppose we have five charges arranged along the x- and y-axes of a coordinate system, as shown at right. All of the charges = +0.5 coulomb. The distances of the charges from the coordinate origin are Q_1 = 3 m, Q_2 = 3 m, Q_3 = 3 m, Q_4 = 2m, and Q_5 (at center) = 0. What is the direction and magnitude of the force acting on the center charge?

Solution

Since all of the charges are positive, they will all repel each other. By symmetry, Q_1 and Q_3 will balance and we can neglect them. The forces from Q_2 and Q_4 will act along the y-axis (in opposite directions) with a magnitude given by:

$F = -k(+0.5\ C)(+0.5\ C) / (2\ m)^2 + k(+0.5\ C)(+0.5\ C) / (3\ m)^2 = (k/4)(-{}^1/_4 + {}^1/_9) = -3.1 \times 10^8$ N.

That is, the force direction is along the negative y-axis.

2) The *positron* is a particle which has the same mass and charge as the electron, except that it has a positive charge rather than a negative one. Suppose I place a positron at the x-y coordinates (+3 nm, +4 nm), and I place an electron at the coordinates (–2 nm, –1 nm). (A nm = 10^{-9} m.)

a) What is the magnitude of the dipole moment of this electron-positron pair?

Answer: p = qd, where d in this case is $[(3 - (-2))^2 + (4 - (-1))^2]^{1/2}$ = 7.07 nm.
$p = (1.602 \times 10^{-19}\ C)(7.07 \times 10^{-9}\ m) = 1.13 \times {}^{-27}$ C-m.

b) Suppose I place an electric field of +4000 N/C **j** across the dipole. What is the potential energy of the dipole?

Answer: The dipole is pointing from (–2 nm, –1 nm) to (+3 nm, +4 nm), which means that it has a slope of 5 over 5, i.e., it is pointing at a 45° angle with respect to the **j** axis. This yields a potential energy of $U = -pE \cos\theta = -(1.13 \times 10^{-27}\ C\text{-}m)(4000\ N/C) \cos(45°) = -3.2 \times 10^{-24}$ J

c) How much energy would I need to add to the dipole to bring its potential energy to its maximum possible level?

Answer: The maximum possible energy of the dipole is U = pE, so the necessary energy needed to raise it up would be $(1.13 \times 10^{-27}\ C\text{-}m)(4000\ N/C) - (-3.2 \times 10^{-24}\ J) = 7.72 \times 10^{-24}$ J