NAME & ID ______________________________

PH 102 / LeClair Summer II 2009

Quiz 2: Electrostatics

$$\vec{F}_{12} = k_e \frac{q_1 q_2}{r_{12}^2}\,\hat{\boldsymbol{r}}_{12} = q\vec{E} \qquad k_e \approx 9\times 10^9 \left[\frac{\mathrm{N\cdot m^2}}{\mathrm{C^2}}\right]$$
$$e = 1.6\times 10^{-19}\ [\mathrm{C}] \qquad m_e = 9.11\times 10^{-31}\ [\mathrm{kg}]$$

1. An electron (of charge $-e$ and mass m_e) enters a region of uniform electric field $\vec{E} = 200\,\hat{\boldsymbol{x}}$ [N/C] with velocity $\vec{v}_i = 3.0\times 10^6\,\hat{\boldsymbol{x}}$ [m/s]. What is magnitude the acceleration $|\vec{a}|$ of the electron due to the electric field? Recall $\vec{F} = m\vec{a}$.

The presence of an electric field gives rise to an acceleration through the electric force:

$$\vec{F}_e = q\vec{E} = m\vec{a}$$

Since $\vec{E}$ is in the $\hat{\boldsymbol{x}}$ direction, the acceleration $\vec{a}$ due to that field will be in the $\hat{\boldsymbol{x}}$ direction as well, we can drop the vector notation. Using the quantities given, and rearranging the above:

$$a = \frac{qE}{m} = \frac{-eE}{m_e} = \frac{\left(-1.6\times 10^{-19}\,[\mathrm{C}]\right)(200\,[\mathrm{N/C}])}{9.11\times 10^{-31}\,[\mathrm{kg}]} = -3.5\times 10^{13}\,[\mathrm{N/kg}] = -3.5\times 10^{13}\,\mathrm{m/s^2}$$

2. Two charges of $+1\,\mu$C each are separated by 1 cm. What is the force between them?

We just need to plug the numbers into Coulomb's law:

$$F = k_e\frac{q_1 q_2}{r_{12}^2} = (9\times 10^9\,\frac{\mathrm{N\cdot m^2}}{\mathrm{C^2}})\frac{(1\times 10^{-6}\,\mathrm{C})(1\times 10^{-6}\,\mathrm{C})}{(10^{-2}\,\mathrm{m})^2} = (9\times 10^9)\frac{1\times 10^{-12}}{10^{-4}}\,\mathrm{N} \approx 90\,\mathrm{N}$$

3. Two charges of $+1\,\mu$C are separated by 1 cm. What is the magnitude of the electric field halfway between them?

Zero. Halfway between, the magnitude of the field from each individual charge is the same, but they act in opposite directions. Therefore, exactly in the middle, they cancel, and the field is zero. This is the same as the field exactly at the midpoint of an electric dipole. It might be easier to convince yourself the field is zero if you draw a picture including the electric field lines.