Quiz 2: Solutions

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

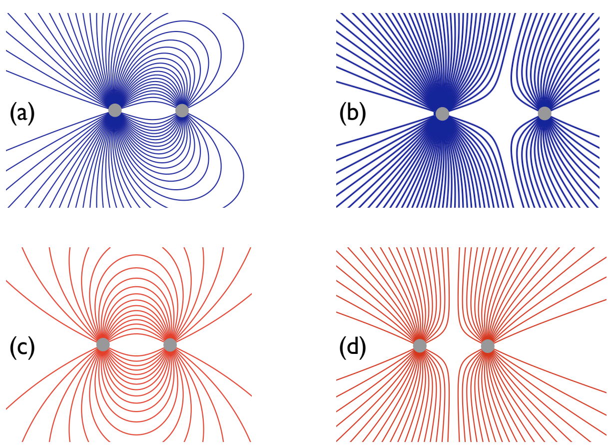
The presence of an electric field gives rise to an acceleration through the electric force:

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

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

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

2. Which set of electric field lines below could represent the electric field near two charges of the *same sign*, but *different magnitudes*?



Set **(b)**. If the charges are of the *opposite* sign, then the field lines would have to run from one charge directly to the other. Field lines start on a positive charge and end on a negative one, and there should be many lines which run from one charge to the other. Since opposite charges attract, the field between them is extremely strong, the lines should be densest right between the charges. This is the case in (a) and (c), so they are not the right ones.

By the same token, for charges of the *same* sign, the force is repulsive, and the electric field midway between them cancels. The field lines should "push away" from each other, and no field line from a given charge should reach the other charge – field lines cannot start and end on the same sign charge. This means that only (b) and (d) could possibly correspond to two charges of the same sign.

Next, the field lines leaving or entering a charge has to be proportional to the magnitude of the charge. In (d) there are the same number of lines entering and leaving each charge, so the charges are of the same magnitude. One can also see this from the fact that the lines are symmetric about a vertical line drawn midway between the charges. In (b) there are clearly many more lines near the left-most charge.

Or, right off the bat, you could notice that only (a) and (b) are asymmetric, and only (b) and (d) could be two like charges. No sense in over-thinking this one.

3. A "free" electron and a "free" proton are placed in an identical electric field. Which of the following statements are true? *Check all that apply.* Note the electron mass and proton mass above.

- □ Each particle is acted on by the same electric force and has the same acceleration.
- □ The electric force on the proton is greater in magnitude than the force on the electron, but in the opposite direction.
- ■ The electric force on the proton is equal in magnitude to the force on the electron, but in the opposite direction.
- ■ The magnitude of the acceleration of the electron is greater than that of the proton.
- □ Both particles have the same acceleration.

Since both particles have the same magnitude of charge $|e|$, they both feel the same electric force F_e. The forces must be in opposite directions, since protons and electrons have charges of opposite sign. However, since the electron is far lighter than the proton, it feels a much larger acceleration, $a = F_e/m$