A charged object creates an electric field at all locations in the space around it. Electric field is a vector—it has both a magnitude and a direction at every location. If the charged object is a point charge (call it $q_1$) then the electric field created by $q_1$ at a distance $r$ from $q_1$ is given by:

$$E_1 = k \frac{|q_1|}{r^2}, \quad k \equiv 8.99 \times 10^9 \frac{Nm^2}{C^2} \quad (1)$$

$E_1$ points directly away from $q_1$ if $q_1$ is positive; $E_1$ points directly toward $q_1$ if $q_1$ is negative.

If there is some other point charge $q_2$ that is placed at a location where there is an electric field $\vec{E}$ created by something else, then $q_2$ will feel a force $\vec{F}_2$ given by:

$$\vec{F}_2 = q_2 \vec{E}_2 \quad (2)$$

if $q_2$ is positive, then $\vec{F}_2$ points in the same direction as $\vec{E}$;

if $q_2$ is negative, then $\vec{F}_2$ points in the opposite direction as $\vec{E}$.

It is important to understand that these two equations are talking about different things. The first equation tells you about how a point charge creates an electric field. It says nothing about forces.

The second equation tells you that an electric field created by something else will apply a force on a charge located in that field. But it says nothing about what created the field.

**Problems** Useful constants: $[e = 1.6 \times 10^{-19}$ C, $m_{\text{electron}} = 9.1 \times 10^{-31}$ kg]

(1) A uniform electric field $\vec{E}$ has a magnitude of 4300 N/C and points directly upward, as shown in the sketch. An electron is located in the field as shown.

(a) Find the acceleration of the electron.

$$a = \frac{qE}{m} = \frac{(1.6 \times 10^{-19} \text{ C})(4300 \text{ N/C})}{(9.11 \times 10^{-31} \text{ kg})}$$

$$a = 7.6 \times 10^{14} \text{ m/s}^2$$

DOWNWARD (OPPOSITE TO THE FIELD DIRECTION)
1(b) If the electron start off at rest, where will it be after 15 μs?

\[ s = \frac{1}{2} at^2 = \frac{1}{2} (7.55 \times 10^{14} \text{ m/s}^2) (15 \times 10^{-6})^2 \]

\[ s = 8.5 \times 10^4 \text{ m lower} \]

NOTE THAT THIS ISN'T PHYSICAL, AS THE ELECTRON WOULD BE TRAVELLING AT \( v = 1.1 \times 10^{10} \text{ m/s} \) WHICH IS MUCH FASTER THAN THE SPEED OF LIGHT, WE SHOULD HAVE USED A SHORTER TIME!

(2) The magnitude of each of the charges in the figure below is \( 5.50 \times 10^{-12} \text{ C} \). The rectangle is 4.00 cm high and 5.00 cm wide.

(a) On the diagram, draw the direction of the electric field at the center of the rectangle.

(b) Find the magnitude of the electric field at the center of the rectangle.

\[ E = \frac{2|q|}{r^2} = \frac{2(9 \times 10^9 \text{ Nm}^2/\text{C}^2)(5.5 \times 10^{-12} \text{ C})}{(0.032 \text{ m})^2} \]

\[ E = 967 \text{ N/C} \]

**NOT ASKED FOR:**

\[ \theta = \tan^{-1} \left( \frac{2.5 \text{ cm}}{2 \text{ cm}} \right) = 53.00^\circ \]