9. **REASONING** The only force acting on the moving charge is the conservative electric force. Therefore, the total energy of the charge remains constant. Applying the principle of conservation of energy between locations A and B, we obtain

\[
\frac{1}{2} m v_A^2 + E_{PEA} = \frac{1}{2} m v_B^2 + E_{PEB}
\]

Since the charged particle starts from rest, \( v_A = 0 \) m/s. The difference in potential energies is related to the difference in potentials by Equation 19.4, \( E_{PEB} - E_{PEA} = q(V_B - V_A) \). Thus, we have

\[
q(V_A - V_B) = \frac{1}{2} m v_B^2
\]  

(1)

Similarly, applying the conservation of energy between locations C and B gives

\[
q(V_C - V_B) = \frac{1}{2} m (2v_B)^2
\]  

(2)

Dividing Equation (1) by Equation (2) yields

\[
\frac{V_A - V_B}{V_C - V_B} = \frac{1}{4}
\]

This expression can be solved for \( V_B \).

**SOLUTION** Solving for \( V_B \), we find that

\[
V_B = \frac{4V_A - V_C}{3} = \frac{4(452 \text{ V}) - 791 \text{ V}}{3} = 339 \text{ V}
\]
15. **REASONING** Initially, suppose that one charge is at C and the other charge is held fixed at B. The charge at C is then moved to position A. According to Equation 19.4, the work $W_{CA}$ done by the electric force as the charge moves from C to A is $W_{CA} = q(V_C - V_A)$, where, from Equation 19.6, $V_C = \frac{kq}{d}$ and $V_A = \frac{kq}{r}$. From the figure at the right we see that $d = \sqrt{r^2 + r^2} = \sqrt{2}r$. Therefore, we find that

$$W_{CA} = q \left( \frac{kq}{\sqrt{2}r} - \frac{kq}{r} \right) = \frac{kq^2}{r} \left( \frac{1}{\sqrt{2}} - 1 \right)$$

**SOLUTION** Substituting values, we obtain

$$W_{CA} = \left( \frac{8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2 \cdot 3.0 \times 10^{-6} \text{ C}}{0.500 \text{ m}} \right) \left( \frac{1}{\sqrt{2}} - 1 \right) = -4.7 \times 10^{-2} \text{ J}$$

---

31. **REASONING AND SOLUTION** As described in the problem statement, the charges jump between your hand and a doorknob. If we assume that the electric field is uniform, Equation 19.7 applies, and we have

$$E = \frac{\Delta V}{\Delta s} = -\frac{V_{\text{knob}} - V_{\text{hand}}}{\Delta s}$$

Therefore, solving for the potential difference between your hand and the doorknob, we have

$$V_{\text{knob}} - V_{\text{hand}} = -E \Delta s = -(-3.0 \times 10^6 \text{ N} / \text{C})(3.0 \times 10^{-3} \text{ m}) = +9.0 \times 10^3 \text{ V}$$

---

59. **REASONING** If we assume that the motion of the proton and the electron is horizontal in the $+x$ direction, the motion of the proton is determined by Equation 2.8, $x = v_0 t + \frac{1}{2} a_p t^2$, where $x$ is the distance traveled by the proton, $v_0$ is its initial speed, and $a_p$ is its acceleration. If the distance between the capacitor places is $d$, then this relation becomes $\frac{1}{2}d = v_0 t + \frac{1}{2} a_p t^2$, or

$$d = 2v_o t + a_p t^2$$

(1)
We can solve Equation (1) for the initial speed \( v_0 \) of the proton, but, first, we must determine the time \( t \) and the acceleration \( a_p \) of the proton. Since the proton strikes the negative plate at the same instant the electron strikes the positive plate, we can use the motion of the electron to determine the time \( t \).

For the electron, \( \frac{1}{2}d = \frac{1}{2}a_t t^2 \), where we have taken into account the fact that the electron is released from rest. Solving this expression for \( t \) we have \( t = \sqrt{\frac{d}{a_e}} \). Substituting this expression into Equation (1), we have

\[
d = 2v_0 \sqrt{\frac{d}{a_e}} + \left( \frac{a_p}{a_e} \right) d
\]

(2)

The accelerations can be found by noting that the magnitudes of the forces on the electron and proton are equal, since these particles have the same magnitude of charge. The force on the electron is \( F = eE = eV/d \), and the acceleration of the electron is, therefore,

\[
a_e = \frac{F}{m_e} = \frac{eV}{m_e d}
\]

(3)

Newton's second law requires that \( m_e a_e = m_p a_p \), so that

\[
\frac{a_p}{a_e} = \frac{m_e}{m_p}
\]

(4)

Combining Equations (2), (3) and (4) leads to the following expression for \( v_0 \), the initial speed of the proton:

\[
v_0 = \frac{1}{2} \left( 1 - \frac{m_e}{m_p} \right) \sqrt{\frac{eV}{m_e}}
\]

\[\text{SOLUTION}\]

Substituting values into the expression above, we find

\[
v_0 = \frac{1}{2} \left( 1 - \frac{9.11 \times 10^{-31} \text{ kg}}{1.67 \times 10^{-27} \text{ kg}} \right) \sqrt{\frac{1.6 \times 10^{-19} \text{ C}(175 \text{ V})}{9.11 \times 10^{-31} \text{ kg}}} = 2.77 \times 10^6 \text{ m/s}
\]