21. Since this problem involves constant downward acceleration of magnitude a, similar to the projectile motion situation, we use the equations of §4-6 as long as we substitute a for g. We adopt the positive direction choices used in the textbook so that equations such as Eq. 4-22 are directly applicable. The initial velocity is horizontal so that $v_{0y} = 0$ and $v_{0x} = v_0 = 1.0 \times 10^9$ cm/s.

(a) If ℓ is the length of a plate and t is the time an electron is between the plates, then $\ell = v_0 t$, where v_0 is the initial speed. Thus

$$t = \frac{\ell}{v_0} = \frac{2.0\,\text{cm}}{1.0 \times 10^9\,\text{cm/s}} = 2.0 \times 10^{-9}\ \text{s}\ .$$

(b) The vertical displacement of the electron is

$$y = -\frac{1}{2}at^2 = -\frac{1}{2}\left(1.0 \times 10^{17}\,\text{cm/s}^2\right)\left(2.0 \times 10^{-9}\,\text{s}\right)^2 = -0.20\ \text{cm}\ .$$

(c) and (d) The x component of velocity does not change: $v_x = v_0 = 1.0 \times 10^9$ cm/s, and the y component is

$$v_y = a_y t = \left(1.0 \times 10^{17}\,\text{cm/s}^2\right)\left(2.0 \times 10^{-9}\,\text{s}\right) = 2.0 \times 10^8\,\text{cm/s}\ .$$