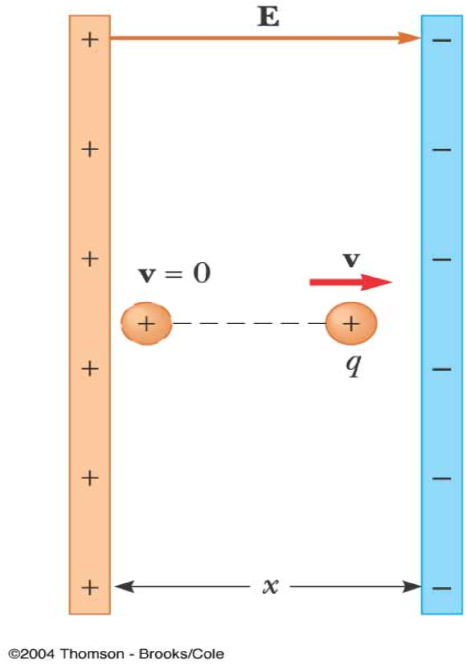
## 23.7 Motion of Charged Particle in Uniform Electric Field




When a particle of charge $q$ and mass $m$ is placed in an electric field **E**, the electric force exerted on the charge is ***q*E**. If this is the only force exerted on the particle, it must be the net force and so must cause the particle to accelerate. In this case, Newton's second law applied to the particle gives;

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

Then, the acceleration of the particle is

$$\vec{a} = \frac{q\vec{E}}{m}$$

**Please note that:**

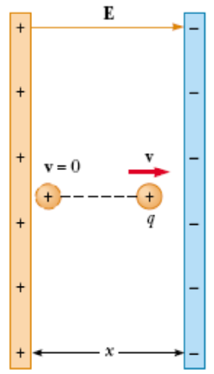
- If E is uniform (that is, **constant in magnitude and direction**), then the acceleration is constant.
- If the particle has a **positive** charge, then its acceleration is **in the direction of the electric field**.
- If the particle has a **negative** charge, then its acceleration is **in the direction opposite the electric field.**

The kinetic energy of the charge after it has moved a distance $x = x_f - x_i$, is

$$K = \tfrac{1}{2}mv^2 = \tfrac{1}{2}m\left(\frac{2qE}{m}\right)x = qEx$$

We can also obtain this result from the work–kinetic energy theorem because the work done by the electric force is $F_e x = qEx$ and $W = \Delta K$

**EXAMPLE 23.10** **An Accelerating Positive Charge**




A positive point charge *q* of mass *m* is released from rest in a uniform electric field E directed along the *x* axis. Describe its motion.

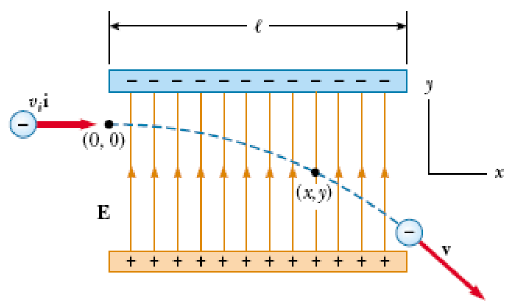
we can apply the equations of kinematics in one dimension

$$x_f = x_i + v_{xi}t + \tfrac{1}{2}a_x t^2$$
$$v_{xf} = v_{xi} + a_x t$$
$$v_{xf}^2 = v_{xi}^2 + 2a_x(x_f - x_i)$$

Taking $x_i = 0$ and $v_{xi} = o$

$$x_f = \tfrac{1}{2}a_x t^2 = \frac{qE}{2m}t^2$$
$$v_{xf} = a_x t = \frac{qE}{m}t$$
$$v_{xf}^2 = 2a_x x_f = \left(\frac{2qE}{m}\right)x_f$$

**Example: 23.11**




**An electron enters the region of a uniform electric field with $v_o$=3.00x10$^6$ m/s and E= 200 N/C. The horizontal length of the plates is l = 0.100 m.**

**(a) Find the acceleration of the electron while it is in the electric field.**

**(b) Find the time it takes the electron to travel through**

**the field.**

**(c) What is the vertical displacement *y* of the electron while it is in the field?**