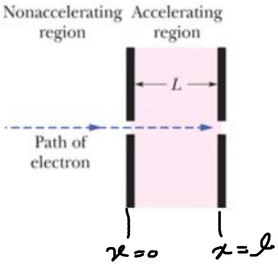
23 E SSM An electron with an initial velocity $v_0 = 1.50 \times 10^5$ m/s enters a region of length $L = 1.00$ cm where it is electrically accelerated (Fig. 2.11). It emerges with $v = 5.70 \times 10^6$ m/s. What is its acceleration, assumed constant?



$v_0 = 1.5 \times 10^5$ m/s

$\ell = 1.00$ cm $= 10^{-2}$ m

$v = 5.70 \times 10^6$ m/s

$\Rightarrow \Delta x = \ell$

$$a = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{\underset{?}{t} - \cancel{t_0}_{\,0}} \rightarrow t = \frac{v - v_0}{a}$$

$$x = \tfrac{1}{2} a t^2 + v_0 t + x_0 \rightarrow x - x_0 = \tfrac{1}{2} \cancel{a} \times \frac{(v - v_0)^2}{a^{\cancel{2}}} + v_0 \times \frac{v - v_0}{a}$$

$$\rightarrow x - x_0 = \frac{v - v_0}{2a} \left\{ \underbrace{v - v_0 + 2v_0}_{v + v_0} \right\} \rightarrow x - x_0 = \frac{\overset{= v^2 - v_0^2}{(v - v_0)(v + v_0)}}{2a}$$

$$\rightarrow v^2 - v_0^2 = 2a \, \Delta x \rightarrow \underbrace{(5.7)^2 \times 10^{12} - (1.5)^2 \times 10^{10}}_{10^{10} \{ 32.49 \times 10^2 - 2.25 \}} = 2a \times 10^{-2}$$

$$\Rightarrow a = \overset{10^{12}}{\frac{10^{10}}{10^{-2}}} \times \underbrace{\frac{3249 - 2.25}{2}}_{1623.3 = 1.62 \times 10^3} \Rightarrow a = 1.62 \times 10^{15} \ m/s^2$$

24 E BIO FCP *Catapulting mushrooms.* Certain mushrooms launch their spores by a catapult mechanism. As water condenses from the air onto a spore that is attached to the mushroom, a drop grows on one side of the spore and a film grows on the other side. The spore is bent over by the drop's weight, but when the film reaches the drop, the drop's water suddenly spreads into the film and the spore springs upward so rapidly that it is slung off into the air. Typically, the spore reaches a speed of 1.6 m/s in a 5.0 μm launch; its speed is then reduced to zero in 1.0 mm by the air. Using those data and assuming constant accelerations, find the acceleration in terms of g during (a) the launch and (b) the speed reduction.

a) $v_0 = 0$

$v = 1.6$ m/s

$\Delta x = 5.0 \ \mu m = 5 \times 10^{-6}$ m

$$v^2 - v_0^2 = 2a\Delta x \rightarrow a = \frac{(1.6)^2 - 0}{\underbrace{2 \times 5 \times 10^{-6}}_{} = 10^5} = 2.56 \times 10^5 \ m/s^2$$

$g \simeq 10 \ m/s^2 \Rightarrow a \simeq 2.6 \times 10^4 g$

b) $v_0 = 1.6$ m/s

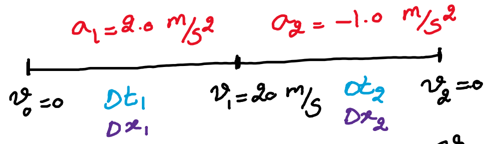
$v = 0$

$\Delta x = 1.0$ mm $= 10^{-3}$ m

$$a = \frac{v^2 - v_0^2}{2\Delta x} = \frac{0 - (1.6)^2}{2 \times 10^{-3}} = -1.28 \times 10^3 \ m/s^2$$

$g \simeq 10 \ m/s^2 \Rightarrow a \simeq -1.3 \times 10^2 g$

25 E An electric vehicle starts from rest and accelerates at a rate of 2.0 m/s^2 in a straight line until it reaches a speed of 20 m/s. The vehicle then slows at a constant rate of 1.0 m/s^2 until it stops. (a) How much time elapses from start to stop? (b) How far does the vehicle travel from start to stop?



a) $a = \dfrac{\Delta v}{\Delta t} \rightarrow a_1 = \dfrac{v_1 - v_0}{\Delta t_1} \Rightarrow \Delta t_1 = \dfrac{20-0}{2} = 10$ s

$a_2 = \dfrac{v_2 - v_1}{\Delta t_2} \Rightarrow \Delta t_2 = \dfrac{0-20}{-1} = 20$ s

$\Rightarrow T = 30$ s

b) $v^2 - v_0^2 = 2a\Delta x \Rightarrow v_1^2 - v_0^2 = 2a_1\Delta x_1 \Rightarrow \Delta x_1 = \dfrac{400-0}{2\times 2} = 100$ m

$v_2^2 - v_1^2 = 2a_2\Delta x_2 \Rightarrow \Delta x_2 = \dfrac{0-400}{2\times(-1)} = 200$ m

$\Rightarrow d = 300$ m

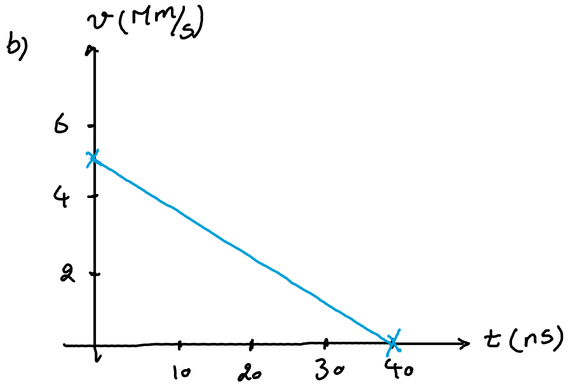
26 E A muon (an elementary particle) enters a region with a speed of 5.00 × 10^6 m/s and then is slowed at the rate of 1.25 × 10^{14} m/s^2. (a) How far does the muon take to stop? (b) Graph *x* versus *t* and *v* versus *t* for the muon.

$v_0 = 5.00 \times 10^6$ m/s

$a = -1.25 \times 10^{14}$ m/s^2

a) $v = 0$; $\overset{0}{\cancel{v}}^2 - v_0^2 = 2a\Delta x \rightarrow \Delta x = \dfrac{-v_0^2}{2a} = \dfrac{\overset{\overset{10}{\cancel{25}\times\cancel{10^{12}}}}{\cancel{+}(5\times10^6)^2}}{\underset{\cancel{2.5}}{2\times(\cancel{-}1.25)}\times\underset{10^2}{\cancel{10^{14}}}} = 10^{-1} = 0.100$ m

b)



$v = at + v_0$

$v = -1.25 \times 10^{14}\, t + 5.00 \times 10^6$

$v(t=0) = v_0 = 5 \times \underset{M}{\underbrace{10^6}}$ m/s $= 5$ Mm/s

$v = 0 \rightarrow -1.25 \times 10^{14}\, t + 5 \times 10^6 = 0$ *

$\rightarrow t = \dfrac{\overset{4}{\cancel{5}} \times \cancel{10^6}}{\cancel{1.25} \times \underset{8}{\cancel{10^{14}}}} = 4 \times 10^{-8}$ s $= 40 \times \underset{ns}{\underbrace{10^{-9}\,\text{s}}}$

$x = \frac{1}{2}at^2 + v_0 t + \overset{0}{\cancel{x_0}}$

$x = \frac{1}{2} \times (-1.25 \times 10^{14})\, t^2 + 5 \times 10^6\, t = -0.625 \times 10^{14}\, t^2 + 5 \times 10^6\, t$

↳ Concave down

$x(t=0) = x_0 = 0$

$\dfrac{dx}{dt} = 0 \xrightarrow{*} t = 40$ ns $\longrightarrow x_{max} = 0.100$ m $= 10$ cm