] An object moving with uniform acceleration has a velocity of 12.0 cm/s in the positive x direction when its x coordinate is 3.00 cm. If its x coordinate 2.00 s later is − 5.00 cm, what is its acceleration?

Given $v_i = 12.0$ cm/s when $x_i = 3.00$ cm$(t = 0)$, and at $t = 2.00$ s, $x_f = -5.00$ cm,

$$x_f - x_i = v_i t + \frac{1}{2}at^2: -5.00 - 3.00 = 12.0(2.00) + \frac{1}{2}a(2.00)^2$$

$$-8.00 = 24.0 + 2a \qquad a = -\frac{32.0}{2} = \boxed{-16.0\ \text{cm/s}^2}.$$

An object moves along the x axis according to the equation $x(t) = (3.00t^2 - 2.00t + 3.00)$ m. Determine (a) the average speed between $t = 2.00$ s and $t = 3.00$ s, (b) the instantaneous speed at $t = 2.00$ s and at $t = 3.00$ s, (c) the average acceleration between $t = 2.00$ s and $t = 3.00$ s, and (d) the instantaneous acceleration at $t = 2.00$ s and $t = 3.00$ s.

(a) At $t = 2.00\ \text{s}$, $x = \left[3.00(2.00)^2 - 2.00(2.00) + 3.00\right]\ \text{m} = 11.0\ \text{m}$.

At $t = 3.00\ \text{s}$, $x = \left[3.00(9.00)^2 - 2.00(3.00) + 3.00\right]\ \text{m} = 24.0\ \text{m}$

so

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{24.0\ \text{m} - 11.0\ \text{m}}{3.00\ \text{s} - 2.00\ \text{s}} = \boxed{13.0\ \text{m/s}}.$$

(b) At all times the instantaneous velocity is

$$v = \frac{d}{dt}\left(3.00t^2 - 2.00t + 3.00\right) = (6.00t - 2.00)\ \text{m/s}$$

At $t = 2.00\ \text{s}$, $v = \left[6.00(2.00) - 2.00\right]\ \text{m/s} = \boxed{10.0\ \text{m/s}}$.

At $t = 3.00\ \text{s}$, $v = \left[6.00(3.00) - 2.00\right]\ \text{m/s} = \boxed{16.0\ \text{m/s}}$.

(c) $\bar{a} = \dfrac{\Delta v}{\Delta t} = \dfrac{16.0\ \text{m/s} - 10.0\ \text{m/s}}{3.00\ \text{s} - 2.00\ \text{s}} = \boxed{6.00\ \text{m/s}^2}$

(d) At all times $a = \dfrac{d}{dt}(6.00 - 2.00) = \boxed{6.00\ \text{m/s}^2}$. (This includes both $t = 2.00\ \text{s}$ and $t = 3.00\ \text{s}$).

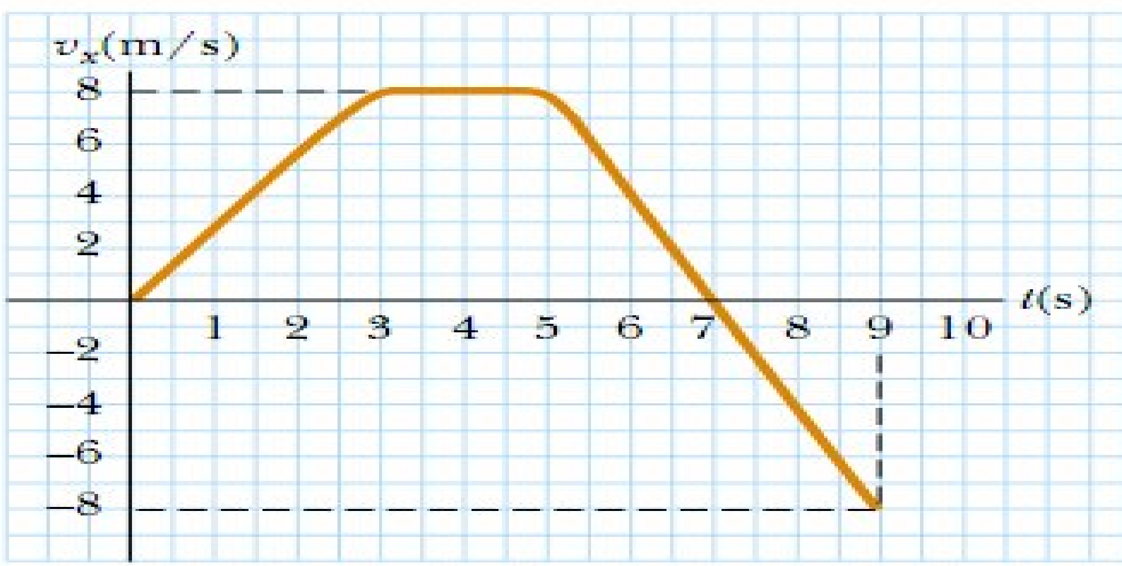
A student throws a set of keys vertically upward to her sorority sister, who is in a window 4.00 m above. The keys are caught 1.50 s later by the sister's outstretched hand. (a) With what initial velocity were the keys thrown? (b) What was the velocity of the keys just before they were caught?

(a) $y_f - y_i = v_i t + \frac{1}{2}at^2$: $4.00 = (1.50)v_i - (4.90)(1.50)^2$ and $v_i = \boxed{10.0\ \text{m/s upward}}$.

(b) $v_f = v_i + at = 10.0 - (9.80)(1.50) = -4.68\ \text{m/s}$

$$v_f = \boxed{4.68\ \text{m/s downward}}$$

A student drives a moped along a straight road as described by the velocity-versus-time graph in Figure P2.54. Sketch this graph in the middle of a sheet of graph paper. (a) Directly above your graph, sketch a graph of the position versus time, aligning the time coordinates of the two graphs. (b) Sketch a graph of the acceleration versus time directly below the v_x-t graph, again aligning the time coordinates. On each graph, show the numerical values of x and a_x for all points of inflection. (c) What is the acceleration at $t = 6$ s? (d) Find the position (relative to the starting point) at $t = 6$ s. (e) What is the moped's final position at $t = 9$ s?



(a) See the graphs at the right.

Choose $x=0$ at $t=0$.

At $t=3\ \text{s}$, $x=\frac{1}{2}(8\ \text{m/s})(3\ \text{s})=12\ \text{m}$.

At $t=5\ \text{s}$, $x=12\ \text{m}+(8\ \text{m/s})(2\ \text{s})=28\ \text{m}$.

At $t=7\ \text{s}$, $x=28\ \text{m}+\frac{1}{2}(8\ \text{m/s})(2\ \text{s})=36\ \text{m}$.

(b) For $0<t<3\ \text{s}$, $a=\dfrac{8\ \text{m/s}}{3\ \text{s}}=2.67\ \text{m/s}^2$.

For $3<t<5\ \text{s}$, $a=0$.

(c) For $5\ \text{s}<t<9\ \text{s}$, $a=-\dfrac{16\ \text{m/s}}{4\ \text{s}}=\boxed{-4\ \text{m/s}^2}$.

(d) At $t=6\ \text{s}$, $x=28\ \text{m}+(6\ \text{m/s})(1\ \text{s})=\boxed{34\ \text{m}}$.

(e) At $t=9\ \text{s}$, $x=36\ \text{m}+\frac{1}{2}(-8\ \text{m/s})(2\ \text{s})=\boxed{28\ \text{m}}$.

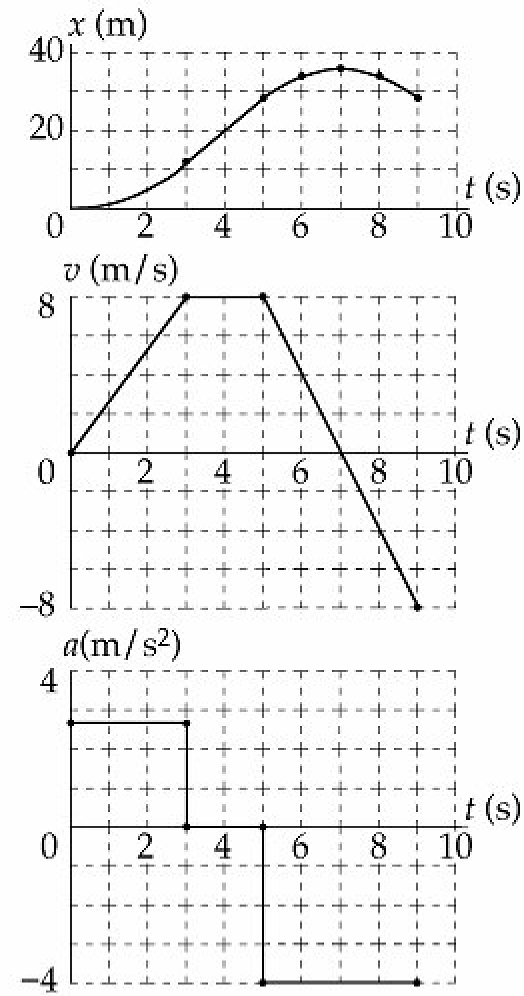


FIG. P2.54

An electron in a cathode ray tube (CRT) accelerates from 2.00×10^4 m/s to 6.00×10^6 m/s over 1.50 cm. (a) How long does the electron take to travel this 1.50 cm? (b) What is its acceleration?

We have $v_i = 2.00\times10^4$ m/s, $v_f = 6.00\times10^6$ m/s, $x_f - x_i = 1.50\times10^{-2}$ m.

(a) $$x_f - x_i = \frac{1}{2}(v_i + v_f)t:\ t = \frac{2(x_f - x_i)}{v_i + v_f} = \frac{2(1.50\times10^{-2}\ \text{m})}{2.00\times10^4\ \text{m/s} + 6.00\times10^6\ \text{m/s}} = \boxed{4.98\times10^{-9}\ \text{s}}$$

(b) $$v_f^2 = v_i^2 + 2a_x(x_f - x_i):$$

$$a_x = \frac{v_f^2 - v_i^2}{2(x_f - x_i)} = \frac{(6.00\times10^6\ \text{m/s})^2 - (2.00\times10^4\ \text{m/s})^2}{2(1.50\times10^{-2}\ \text{m})} = \boxed{1.20\times10^{15}\ \text{m/s}^2}$$

] A particle moves along the x axis according to the equation $x = 2.00 + 3.00t - 1.00t^2$, where x is in meters and t is in seconds. At $t = 3.00$ s, find (a) the position of the particle, (b) its velocity, and (c) its acceleration.

$$x = 2.00 + 3.00t - t^2,\ v = \frac{dx}{dt} = 3.00 - 2.00t,\ a = \frac{dv}{dt} = -2.00$$

At $t = 3.00$ s:

(a) $x = (2.00 + 9.00 - 9.00)\ \text{m} = \boxed{2.00\ \text{m}}$

(b) $v = (3.00 - 6.00)\ \text{m/s} = \boxed{-3.00\ \text{m/s}}$

(c) $a = \boxed{-2.00\ \text{m/s}^2}$