Chapter 2 Motion in One Dimension

P2.1 (a) $v_{avg} = \dfrac{\Delta x}{\Delta t} = \dfrac{10\text{ m}}{2\text{ s}} = \boxed{5\text{ m/s}}$

(b) $v_{avg} = \dfrac{5\text{ m}}{4\text{ s}} = \boxed{1.2\text{ m/s}}$

(c) $v_{avg} = \dfrac{x_2 - x_1}{t_2 - t_1} = \dfrac{5\text{ m} - 10\text{ m}}{4\text{ s} - 2\text{ s}} = \boxed{-2.5\text{ m/s}}$

(d) $v_{avg} = \dfrac{x_2 - x_1}{t_2 - t_1} = \dfrac{-5\text{ m} - 5\text{ m}}{7\text{ s} - 4\text{ s}} = \boxed{-3.3\text{ m/s}}$

(e) $v_{avg} = \dfrac{x_2 - x_1}{t_2 - t_1} = \dfrac{0 - 0}{8 - 0} = \boxed{0\text{ m/s}}$

P2.3 (a) Let d represent the distance between A and B. Let t_1 be the time for which the walker has the higher speed in $5.00\text{ m/s} = \dfrac{d}{t_1}$. Let t_2 represent the longer time for the return trip in $-3.00\text{ m/s} = -\dfrac{d}{t_2}$. Then the times are $t_1 = \dfrac{d}{(5.00\text{ m/s})}$ and $t_2 = \dfrac{d}{(3.00\text{ m/s})}$. The average speed is:

$$v_{avg} = \frac{\text{Total distance}}{\text{Total time}} = \frac{d + d}{d/(5.00\text{ m/s}) + d/(3.00\text{ m/s})} = \frac{2d}{(8.00\text{ m/s})d/(15.0\text{ m}^2/\text{s}^2)}$$

$$v_{avg} = \frac{2(15.0\text{ m}^2/\text{s}^2)}{8.00\text{ m/s}} = \boxed{3.75\text{ m/s}}$$

(b) She starts and finishes at the same point A. With total displacement = 0, average
velocity $= \boxed{0}$.

P2.4 $x = 10t^2$: By substitution, for

$t(\text{s})$	=	2.0	2.1	3.0
$x(\text{m})$	=	40	44.1	90

(a) $v_{avg} = \dfrac{\Delta x}{\Delta t} = \dfrac{50\text{ m}}{1.0\text{ s}} = \boxed{50.0\text{ m/s}}$

(b) $v_{avg} = \dfrac{\Delta x}{\Delta t} = \dfrac{4.1\text{ m}}{0.1\text{ s}} = \boxed{41.0\text{ m/s}}$

P2.5 (a) at $t_i = 1.5\text{ s}$, $x_i = 8.0\text{ m}$ (Point A)
at $t_f = 4.0\text{ s}$, $x_f = 2.0\text{ m}$ (Point B)

$$v_{avg} = \frac{x_f - x_i}{t_f - t_i} = \frac{(2.0-8.0)\text{ m}}{(4-1.5)\text{ s}} = -\frac{6.0\text{ m}}{2.5\text{ s}} = \boxed{-2.4\text{ m/s}}$$

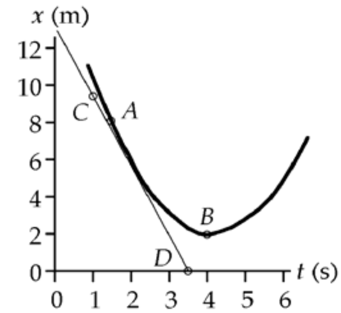


FIG. P2.5

(b) The slope of the tangent line can be found from points *C* and *D*. $(t_C = 1.0\text{ s}, x_C = 9.5\text{ m})$ and $(t_D = 3.5\text{ s}, x_D = 0)$,

$$v \approx \boxed{-3.8\text{ m/s}}.$$

(c) The velocity is zero when *x* is a minimum. This is at $t \approx \boxed{4\text{ s}}$.

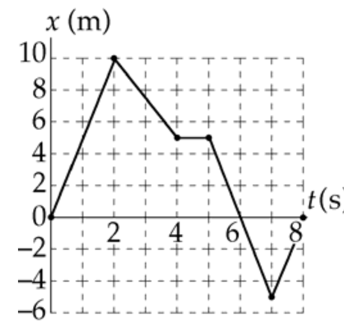


FIG. P2.8

P2.8 (a) $v = \frac{(5-0)\text{ m}}{(1-0)\text{ s}} = \boxed{5\text{ m/s}}$

(b) $v = \frac{(5-10)\text{ m}}{(4-2)\text{ s}} = \boxed{-2.5\text{ m/s}}$

(c) $v = \frac{(5\text{ m} - 5\text{ m})}{(5\text{ s} - 4\text{ s})} = \boxed{0}$

(d) $v = \frac{0-(-5\text{ m})}{(8\text{ s} - 7\text{ s})} = \boxed{+5\text{ m/s}}$

P2.9 Once it resumes the race, the hare will run for a time of

$$t = \frac{x_f - x_i}{v_x} = \frac{1\,000\text{ m} - 800\text{ m}}{8\text{ m/s}} = 25\text{ s}.$$

In this time, the tortoise can crawl a distance

$$x_f - x_i = (0.2\text{ m/s})(25\text{ s}) = \boxed{5.00\text{ m}}.$$

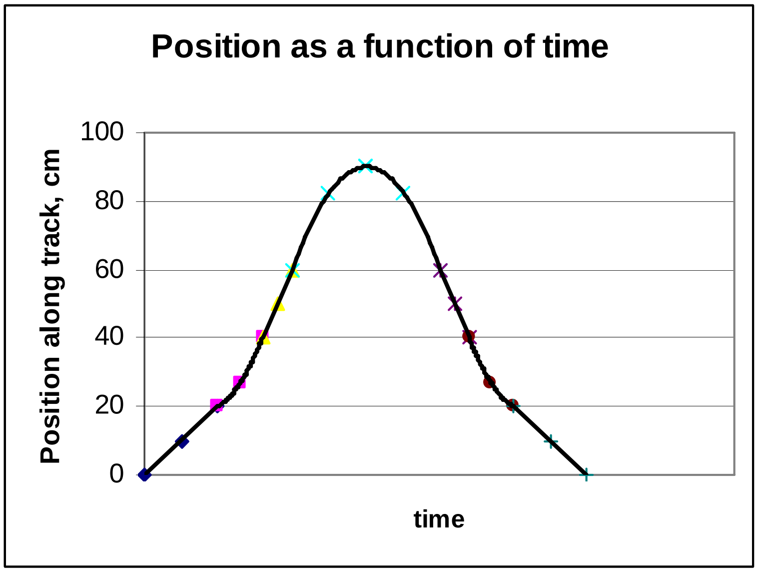
P2.13 $x = 2.00 + 3.00t - t^2$, so $v = \frac{dx}{dt} = 3.00 - 2.00t$, and $a = \frac{dv}{dt} = -2.00$
At $t = 3.00\text{ s}$:

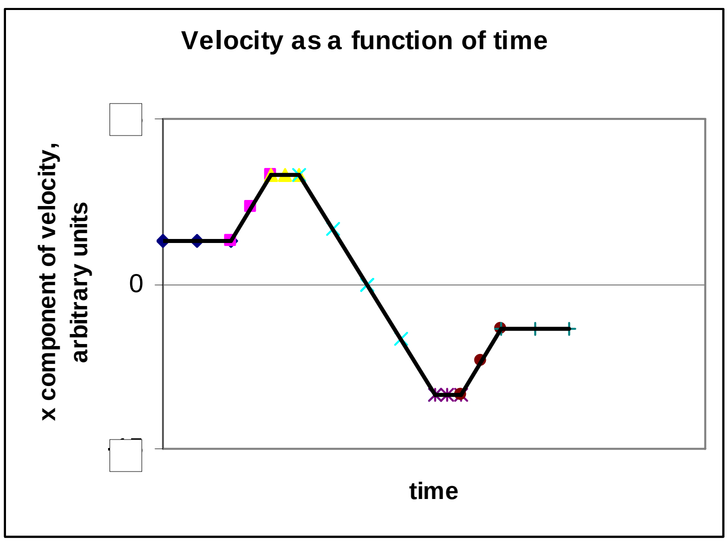
(a) $x = (2.00 + 9.00 - 9.00)\text{ m} = \boxed{2.00\text{ m}}$

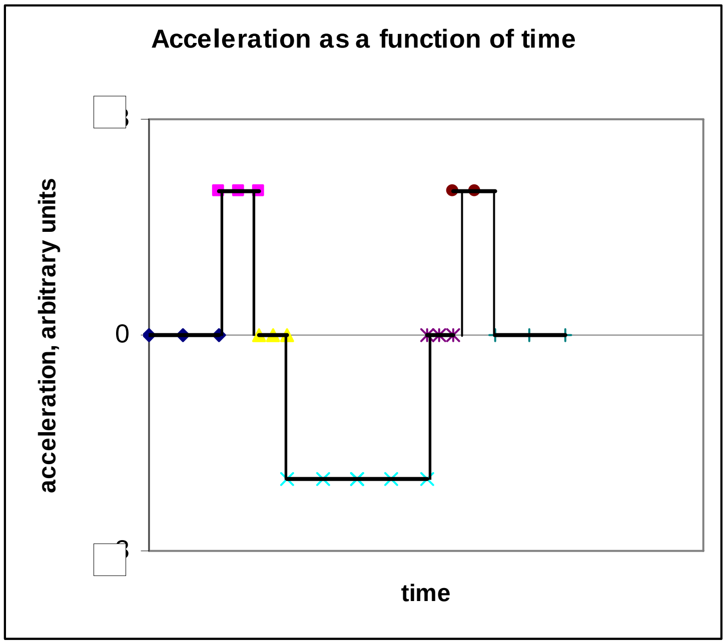
(b) $v = (3.00 - 6.00)\text{ m/s} = \boxed{-3.00\text{ m/s}}$

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

***P2.14** The acceleration is zero whenever the marble is on a horizontal section. The acceleration has a constant positive value when the marble is rolling on the 20-to-40-cm section and has a constant negative value when it is rolling on the second sloping section. The position graph is a straight sloping line whenever the speed is constant and a section of a parabola when the speed changes.







P2.15 (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

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

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

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

P2.23 (a) $v_i = 100\text{ m/s}$, $a = -5.00\text{ m/s}^2$, $v_f = v_i + at$ so $0 = 100 - 5t$, $v_f^2 = v_i^2 + 2a(x_f - x_i)$ so $0 = (100)^2 - 2(5.00)(x_f - 0)$. Thus $x_f = 1\,000\text{ m}$ and $t = \boxed{20.0\text{ s}}$.

(b) 1 000 m is greater than 800 m. With this acceleration $\boxed{\text{the plane would overshoot the runway: it cannot land}}$.

P2.25 In the simultaneous equations:

$$\left\{\begin{array}{c} v_{xf} = v_{xi} + a_x t \\ x_f - x_i = \frac{1}{2}\left(v_{xi} + v_{xf}\right)t \end{array}\right\} \text{ we have } \left\{\begin{array}{c} v_{xf} = v_{xi} - \left(5.60 \text{ m/s}^2\right)(4.20 \text{ s}) \\ 62.4 \text{ m} = \frac{1}{2}\left(v_{xi} + v_{xf}\right)(4.20 \text{ s}) \end{array}\right\}.$$

So substituting for v_{xi} gives $62.4 \text{ m} = \frac{1}{2}\left[v_{xf} + \left(5.60 \text{ m/s}^2\right)(4.20 \text{ s}) + v_{xf}\right](4.20 \text{ s})$

$$14.9 \text{ m/s} = v_{xf} + \frac{1}{2}\left(5.60 \text{ m/s}^2\right)(4.20 \text{ s}).$$

Thus

$$v_{xf} = \boxed{3.10 \text{ m/s}}.$$

P2.28 (a) Compare the position equation $x = 2.00 + 3.00t - 4.00t^2$ to the general form

$$x_f = x_i + v_i t + \frac{1}{2}at^2$$

to recognize that $x_i = 2.00 \text{ m}$, $v_i = 3.00 \text{ m/s}$, and $a = -8.00 \text{ m/s}^2$. The velocity equation, $v_f = v_i + at$, is then

$$v_f = 3.00 \text{ m/s} - \left(8.00 \text{ m/s}^2\right)t.$$

The particle changes direction when $v_f = 0$, which occurs at $t = \frac{3}{8} \text{ s}$. The position at this time is

$$x = 2.00 \text{ m} + (3.00 \text{ m/s})\left(\frac{3}{8} \text{ s}\right) - \left(4.00 \text{ m/s}^2\right)\left(\frac{3}{8} \text{ s}\right)^2 = \boxed{2.56 \text{ m}}.$$

(b) From $x_f = x_i + v_i t + \frac{1}{2}at^2$, observe that when $x_f = x_i$, the time is given by $t = -\frac{2v_i}{a}$. Thus, when the particle returns to its initial position, the time is

$$t = \frac{-2(3.00 \text{ m/s})}{-8.00 \text{ m/s}^2} = \frac{3}{4} \text{ s}$$

and the velocity is $v_f = 3.00 \text{ m/s} - \left(8.00 \text{ m/s}^2\right)\left(\frac{3}{4} \text{ s}\right) = \boxed{-3.00 \text{ m/s}}$.

P2.32 Take the original point to be when Sue notices the van. Choose the origin of the *x*-axis at Sue's car. For her we have $x_{is} = 0$, $v_{is} = 30.0 \text{ m/s}$, $a_s = -2.00 \text{ m/s}^2$ so her position is given by

$$x_s(t) = x_{is} + v_{is}t + \frac{1}{2}a_s t^2 = (30.0 \text{ m/s})t + \frac{1}{2}\left(-2.00 \text{ m/s}^2\right)t^2.$$

For the van, $x_{iv} = 155 \text{ m}$, $v_{iv} = 5.00 \text{ m/s}$, $a_v = 0$ and

$$x_v(t) = x_{iv} + v_{iv}t + \frac{1}{2}a_v t^2 = 155 + (5.00\ \text{m/s})t + 0\,.$$

To test for a collision, we look for an instant t_c when both are at the same place:

$$\begin{aligned} 30.0t_c - t_c^2 &= 155 + 5.00t_c \\ 0 &= t_c^2 - 25.0t_c + 155. \end{aligned}$$

From the quadratic formula

$$t_c = \frac{25.0 \pm \sqrt{(25.0)^2 - 4(155)}}{2} = 13.6\ \text{s or } \boxed{11.4\ \text{s}}\,.$$

The roots are real, not imaginary, so $\boxed{\text{there is a collision}}$. The smaller value is the collision time. (The larger value tells when the van would pull ahead again if the vehicles could move through each other). The wreck happens at position

$$155\ \text{m} + (5.00\ \text{m/s})(11.4\ \text{s}) = \boxed{212\ \text{m}}\,.$$

***P2.33** (a) Starting from rest and accelerating at $a_b = 13.0\ \text{mi/h}\cdot\text{s}$, the bicycle reaches its maximum speed of $v_{b,\text{max}} = 20.0\ \text{mi/h}$ in a time

$$t_{b,1} = \frac{v_{b,\text{max}} - 0}{a_b} = \frac{20.0\ \text{mi/h}}{13.0\ \text{mi/h}\cdot\text{s}} = 1.54\ \text{s}$$

Since the acceleration a_c of the car is less than that of the bicycle, the car cannot catch the bicycle until some time $t > t_{b,1}$ (that is, until the bicycle is at its maximum speed and coasting). The total displacement of the bicycle at time t is

$$\begin{aligned} \Delta x_b &= \frac{1}{2}a_b t_{b,1}^2 + v_{b,\text{max}}(t - t_{b,1}) \\ &= \left(\frac{1.47\ \text{ft/s}}{1\ \text{mi/h}}\right)\left[\frac{1}{2}\left(13.0\ \frac{\text{mi/h}}{\text{s}}\right)(1.54\ \text{s})^2 + (20.0\ \text{mi/h})(t - 1.54\ \text{s})\right] \\ &= (29.4\ \text{ft/s})t - 22.6\ \text{ft} \end{aligned}$$

The total displacement of the car at this time is

$$\Delta x_c = \frac{1}{2}a_c t^2 = \left(\frac{1.47\ \text{ft/s}}{1\ \text{mi/h}}\right)\left[\frac{1}{2}\left(9.00\ \frac{\text{mi/h}}{\text{s}}\right)t^2\right] = (6.62\ \text{ft/s})t^2$$

At the time the car catches the bicycle $\Delta x_c = \Delta x_b$. This gives

$$(6.62\ \text{ft/s}^2)t^2 = (29.4\ \text{ft/s})t - 22.6\ \text{ft} \qquad \text{or}$$
$$t^2 - (4.44\ \text{s})t + 3.42\ \text{s}^2 = 0$$

that has only one physically meaningful solution $t > t_{b,1}$. This solution gives the total time the bicycle leads the car and is $t = \boxed{3.45\ \text{s}}$.

(b) The lead the bicycle has over the car continues to increase as long as the bicycle is moving faster than the car. This means until the car attains a speed of $v_c = v_{b,\max} = 20.0 \text{ mi/h}$. Thus, the elapsed time when the bicycle's lead ceases to increase is

$$t = \frac{v_{b,\max}}{a_c} = \frac{20.0 \text{ mi/h}}{9.00 \text{ mi/h}\cdot\text{s}} = 2.22 \text{ s}$$

At this time, the lead is

$$(\Delta x_b - \Delta x_c)_{\max} = (\Delta x_b - \Delta x_c)\big|_{t=2.22\text{ s}} = \left[(29.4 \text{ ft/s})(2.22 \text{ s}) - 22.6 \text{ ft}\right] - \left[(6.62 \text{ ft/s}^2)(2.22 \text{ s})^2\right]$$

or $(\Delta x_b - \Delta x_c)_{\max} = \boxed{10.0 \text{ ft}}$.

P2.41 (a) $v_f = v_i - gt$: $v_f = 0$ when $t = 3.00 \text{ s}$, and $g = 9.80 \text{ m/s}^2$. Therefore,

$$v_i = gt = (9.80 \text{ m/s}^2)(3.00 \text{ s}) = \boxed{29.4 \text{ m/s}}.$$

(b) $y_f - y_i = \frac{1}{2}(v_f + v_i)t$

$$y_f - y_i = \frac{1}{2}(29.4 \text{ m/s})(3.00 \text{ s}) = \boxed{44.1 \text{ m}}$$

P2.43 Time to fall 3.00 m is found from the equation describing position as a function of time, with $v_i = 0$, thus: $3.00 \text{ m} = \frac{1}{2}(9.80 \text{ m/s}^2)t^2$, giving $t = 0.782 \text{ s}$.

(a) With the horse galloping at 10.0 m/s, the horizontal distance is $vt = \boxed{7.82 \text{ m}}$.

(b) from above $t = \boxed{0.782 \text{ s}}$

P2.51 Let point 0 be at ground level and point 1 be at the end of the engine burn. Let point 2 be the highest point the rocket reaches and point 3 be just before impact. The data in the table are found for each phase of the rocket's motion.

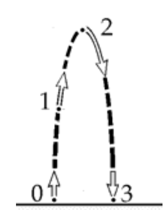


FIG. P2.51

(0 to 1) $v_f^2 - (80.0)^2 = 2(4.00)(1\,000)$ so $v_f = 120 \text{ m/s}$
$120 = 80.0 + (4.00)t$ giving $t = 10.0 \text{ s}$

(1 to 2) $0 - (120)^2 = 2(-9.80)(x_f - x_i)$ giving $x_f - x_i = 735 \text{ m}$
$0 - 120 = -9.80t$ giving $t = 12.2 \text{ s}$
This is the time of maximum height of the rocket.

(2 to 3) $v_f^2 - 0 = 2(-9.80)(-1\,735)$
$v_f = -184 = (-9.80)t$ giving $t = 18.8 \text{ s}$

(a) $t_{\text{total}} = 10 + 12.2 + 18.8 = \boxed{41.0\text{ s}}$

(b) $(x_f - x_i)_{\text{total}} = \boxed{1.73\text{ km}}$

(c) $v_{\text{final}} = \boxed{-184\text{ m/s}}$

		t	x	v	a
0	Launch	0.0	0	80	+4.00
#1	End Thrust	10.0	1 000	120	+4.00
#2	Rise Upwards	22.2	1 735	0	–9.80
#3	Fall to Earth	41.0	0	–184	–9.80

P2.53 (a) Let x be the distance traveled at acceleration a until maximum speed v is reached. If this is achieved in time t_1 we can use the following three equations:

$$x = \frac{1}{2}(v + v_i)t_1,\ 100 - x = v(10.2 - t_1),\ \text{and}\ v = v_i + at_1.$$

The first two give

$$100 = \left(10.2 - \frac{1}{2}t_1\right)v = \left(10.2 - \frac{1}{2}t_1\right)at_1$$

$$a = \frac{200}{(20.4 - t_1)t_1}.$$

$$\text{For Maggie: } a = \frac{200}{(18.4)(2.00)} = \boxed{5.43\text{ m/s}^2}$$

$$\text{For Judy: } a = \frac{200}{(17.4)(3.00)} = \boxed{3.83\text{ m/s}^2}$$

(b) $v = at_1$

$$\text{Maggie: } v = (5.43)(2.00) = \boxed{10.9\text{ m/s}}$$

$$\text{Judy: } v = (3.83)(3.00) = \boxed{11.5\text{ m/s}}$$

(c) At the six-second mark

$$x = \frac{1}{2}at_1^2 + v(6.00 - t_1)$$

$$\text{Maggie: } x = \frac{1}{2}(5.43)(2.00)^2 + (10.9)(4.00) = 54.3\text{ m}$$

$$\text{Judy: } x = \frac{1}{2}(3.83)(3.00)^2 + (11.5)(3.00) = 51.7\text{ m}$$

Maggie is ahead by 54.3 m – 51.7 m = $\boxed{2.62\text{ m}}$. Note that your students may need a reminder that to get the answer in the back of the book they must use calculator memory or a piece of paper to save intermediate results without "rounding off" until the very end.

***P2.54** (a) We first find the distance s_{stop} over which you can stop.

The car travels this distance during your reaction time: $\Delta x_1 = v_0(0.6\text{ s})$.

As you brake to a stop, the average speed of the car is $v_0/2$, the interval of time is $(v_f - v_i)/a = -v_0/(-2.40\text{ m/s}^2) = v_0\text{ s}^2/2.40\text{ m}$, and the braking distance is

$\Delta x_2 = v_{avg}\Delta t = (v_0\text{ s}^2/2.40\text{ m})(v_0/2) = v_0^2\text{ s}^2/4.80\text{ m}$. The total stopping distance is then

$$s_{stop} = \Delta x_1 + \Delta x_2 = v_0(0.6\text{ s}) + v_0^2\text{ s}^2/4.80\text{ m}.$$

If the car is at this distance from the intersection, it can barely brake to a stop, so it should also be able to get through the intersection at constant speed

while the light is yellow, moving a total distance $s_{stop} + 22\text{ m} = v_0(0.6\text{ s}) + v_0^2\text{ s}^2/4.80\text{ m} + 22\text{ m}$. This constant-speed motion requires time

$$\Delta t_y = (s_{stop} + 22\text{ m})/v_0 = (v_0(0.6\text{ s}) + v_0^2\text{ s}^2/4.80\text{ m} + 22\text{ m})/v_0 = \boxed{0.6\text{ s} + v_0\text{ s}^2/4.80\text{ m} + 22\text{ m}/v_0}.$$

(b) Substituting, $\Delta t_y = 0.6\text{ s} + (8\text{ m/s})\text{ s}^2/4.80\text{ m} + 22\text{ m}/(8\text{ m/s}) = 0.6\text{ s} + 1.67\text{ s} + 2.75\text{ s} = \boxed{5.02\text{ s}}$.

(c) We are asked about higher and higher speeds. For 11 m/s instead of 8 m/s, the time is

$0.6\text{ s} + (11\text{ m/s})\text{ s}^2/4.80\text{ m} + 22\text{ m}/(11\text{ m/s}) = \boxed{4.89\text{ s}}$ *less* than we had at the lower speed.

(d) Now the time $0.6\text{ s} + (18\text{ m/s})\text{ s}^2/4.80\text{ m} + 22\text{ m}/(18\text{ m/s}) = \boxed{5.57\text{ s}}$ begins to increase

(e) $0.6\text{ s} + (25\text{ m/s})\text{ s}^2/4.80\text{ m} + 22\text{ m}/(25\text{ m/s}) = \boxed{6.69\text{ s}}$

(f) As v_0 goes to zero, the $22\text{ m}/v_0$ term in the expression for $\boxed{\Delta t_y \text{ becomes large, approaching infinity}}$.

(g) As v_0 grows without limit, the $v_0\text{ s}^2/4.80\text{ m}$ term in the expression for $\boxed{\Delta t_y \text{ becomes large, approaching infinity}}$.

(h) Δt_y decreases steeply from an infinite value at $v_0 = 0$, goes through a rather flat minimum, and

then diverges to infinity as v_0 increases without bound. For a very slowly moving car entering

the intersection and not allowed to speed up, a very long time is required to get

across the
intersection. A very fast-moving car requires a very long time to slow down at the constant
acceleration we have assumed.

(i) To find the minimum, we set the derivative of Δt_y with respect to v_0 equal to zero:

$$\frac{d}{dv_0}\left(0.6\text{ s}+\frac{v_0\text{ s}^2}{4.8\text{ m}}+22\text{ m }v_0^{-1}\right)=0+\frac{\text{s}^2}{4.8\text{ m}}-22\text{ m }v_0^{-2}=0$$

$22\text{ m}/v_0^2=\text{s}^2/4.8\text{ m}$ $\qquad v_0=(22\text{m }[4.8\text{ m/s}^2])^{1/2}=\boxed{10.3\text{ m/s}}$

(j) Evaluating again, $\Delta t_y = 0.6\text{ s} + (10.3\text{ m/s})\ \text{s}^2/4.80\text{ m} + 22\text{ m}/(10.3\text{ m/s}) = \boxed{4.88\text{ s}}$,
just a little less than the answer to part (c).
For some students an interesting project might be to measure the yellow-times of traffic lights on local roadways with various speed limits and compare with the minimum

$\Delta t_{reaction} + (width/2\ |a_{braking}|)^{1/2}$

implied by the analysis here. But do not let the students string a tape measure across the intersection.

***P2.56** (a) From the information in the problem, we model the Ferrari as a particle under constant acceleration. The important "particle" for this part of the problem is the nose of the car. We use the position equation from the particle under constant acceleration model to find the velocity v_0 of the particle as it enters the intersection:

$$x = x_0 + v_0 t + \tfrac{1}{2}at^2$$

$$\rightarrow\quad 28.0\text{ m} = 0 + v_0(3.10\text{ s}) + \tfrac{1}{2}(-2.10\text{ m/s}^2)(3.10\text{ s})^2 \quad\rightarrow\quad v_0 = 12.3\text{ m/s}$$

Now we use the velocity-position equation in the particle under constant acceleration model to find the displacement of the particle from the first edge of the intersection when the Ferrari stops:

$$v^2 = v_0^2 + 2a(x-x_0) \quad\rightarrow\quad x-x_0 = \Delta x = \frac{v^2-v_0^2}{2a} = \frac{0-(12.3\text{ m/s})^2}{2(-2.10\text{ m/s})^2} = \boxed{35.9\text{m}}$$

(b) The time interval during which any part of the Ferrari is in the intersection is that time interval
between the instant at which the nose enters the intersection and the instant when the tail leaves
the intersection. Thus, the change in position of the nose of the Ferrari is 4.52 m + 28.0 m = 32.52 m.
We find the time at which the car is at position x = 32.52 m if it is at x = 0 and moving at 12.3 m/s
at t = 0:

$$x = x_0 + v_0 t + \tfrac{1}{2}at^2 \quad\rightarrow\quad 32.52\text{ m} = 0 + (12.3\text{ m/s})t + \tfrac{1}{2}(-2.10\text{ m/s}^2)t^2$$

$$\rightarrow\quad -1.05t^2 + 12.3t - 32.52 = 0$$

The solutions to this quadratic equation are t = 4.04 s and 7.66 s. Our desired solution is the lower of these, so $t = \boxed{4.04\text{ s}}$. (The later time corresponds to the Ferrari stopping and reversing, which it must do if the acceleration truly remains constant, and arriving again at the position x = 32.52 m.)

(c) We again define t = 0 as the time at which the nose of the Ferrari enters the intersection. Then at time t = 4.04 s, the tail of the Ferrari leaves the intersection. Therefore, to find the minimum distance from the intersection for the Corvette, its nose must enter the intersection at t = 4.04 s. We calculate this distance from the position equation:

$$x - x_0 + v_0 t + \frac{1}{2}at^2 = 0 + 0 + \frac{1}{2}\left(5.60\text{ m/ s}^2\right)\left(4.04\text{ s}\right)^2 = \boxed{45.8\text{ m}}$$

(d) We use the velocity equation:

P2.59 (a) We require $x_s = x_k$ when $t_s = t_k + 1.00$

$$x_s = \frac{1}{2}\left(3.50\text{ m/s}^2\right)\left(t_k + 1.00\right)^2 = \frac{1}{2}\left(4.90\text{ m/s}^2\right)\left(t_k\right)^2 = x_k$$

$$t_k + 1.00 = 1.183t_k$$

$$t_k = \boxed{5.46\text{ s}}.$$

(b) $$x_k = \frac{1}{2}\left(4.90\text{ m/s}^2\right)\left(5.46\text{ s}\right)^2 = \boxed{73.0\text{ m}}$$

(c) $$v_k = \left(4.90\text{ m/s}^2\right)\left(5.46\text{ s}\right) = \boxed{26.7\text{ m/s}}$$

$$v_s = \left(3.50\text{ m/s}^2\right)\left(6.46\text{ s}\right) = \boxed{22.6\text{ m/s}}$$