2–28 A hot-air balloonist, rising vertically with a constant velocity of magnitude 5.00 m/s, releases a sandbag at an instant

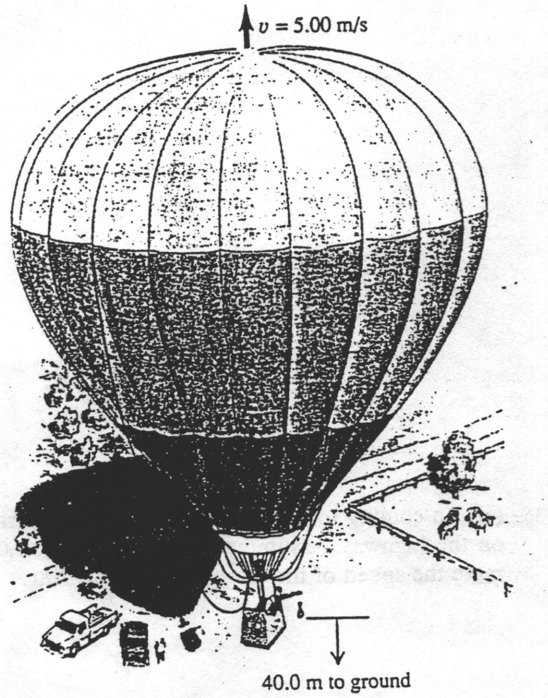


FIGURE 2–29

when the balloon is 40.0 m above the ground (Fig. 2-29). a) Compute the position and velocity of the sandbag at 0.500 s and at 2.00 s after its release. b) How many seconds after its release will the bag strike the ground? c) With what magnitude of velocity does it strike?

2–42 Automobile Airbags. The human body can survive a negative acceleration trauma incident (sudden stop) if the magnitude of the acceleration is less than 250 m/s^2 (approximately $25g$). If you are in an automobile accident at an initial speed of 96 km/h (60 mi/h) and are stopped by an airbag that inflates from the dashboard, over what distance must the airbag stop you for you to survive the crash?

2–45 A car 3.5 m in length and traveling at a constant speed of 20 m/s is approaching an intersection (Fig. 2–33). The width of the intersection is 20 m. The light turns yellow when the front of the car is 50 m from the beginning of the intersection. If the driver steps on the brake, the car will slow at -4.2 m/s^2. If the driver instead steps on the gas pedal, the car will accelerate at 1.5 m/s^2. The light will be yellow for 3.0 s. Ignore the reaction time of the driver. To avoid being in the intersection while the light is red, should the driver hit the brake pedal or the gas pedal?

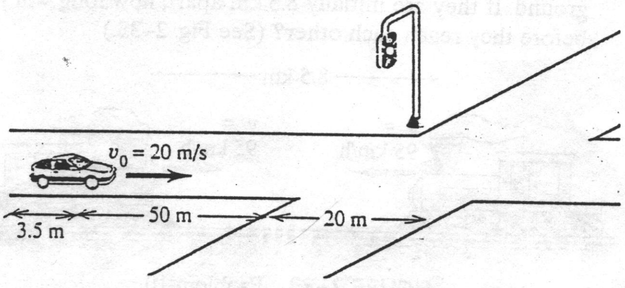


FIGURE 2–33

2–53 Visitors at Great Adventure, an amusement park, are able to watch divers step off a platform 24.4 m (80 ft) above a pool of water. According to the announcer, the divers enter the water at a speed of 65 mi/h (105 km/h). a) Is the announcer correct in this claim? b) Is it possible for a diver to leap directly upward off the board so that, missing the board on the way down, she enters the water at 105 km/h? If so, what initial upward velocity is required? Is the required initial speed physically attainable?

46. [I] A modern supertanker is gigantic: 1200 to 1300 ft long with a 200-ft beam. Fully loaded, it chugs along at about 16 knots (30 km/h or 18 mi/h). It can take 20 min to bring such a monster to a full stop. Calculate the corresponding deceleration in m/s^2 and determine the stopping distance.

71. [I] Calculate the speed at which a hailstone, falling from 3.00×10^4 ft out of a cumulonimbus cloud, would strike the ground, presuming air friction is negligible (which it certainly is not). Give your answer in mi/h and m/s.

10. (II) Two locomotives approach each other on parallel tracks. Each has a speed of 95 km/h with respect to the ground. If they are initially 8.5 km apart, how long will it be before they reach each other? (See Fig. 2–33.)

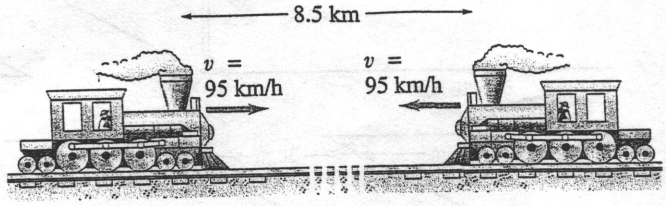


FIGURE 2–33 Problem 10.

36. (II) In coming to a stop, a car leaves skid marks 75 m long on the highway. Assuming a deceleration of $7.00\ m/s^2$, estimate the speed of the car just before braking.

37. (II) A car traveling 55 km/h slows down at a constant $0.50\ m/s^2$ just by "letting up on the gas." Calculate (*a*) the distance the car coasts before it stops, (*b*) the time it takes to stop, and (*c*) the distance it travels during the first and fifth seconds.

62. (II) Suppose you adjust your garden hose nozzle for a hard stream of water. You point the nozzle vertically upward at a height of 1.5 m above the ground (Fig. 2–38). When you quickly move the nozzle away from the vertical, you hear the water striking the ground next to you for another 2.0 s. What is the water speed as it leaves the nozzle?

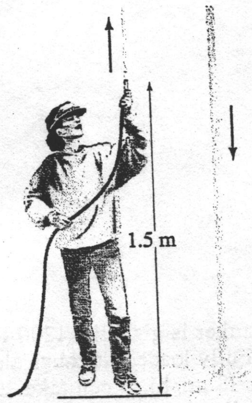
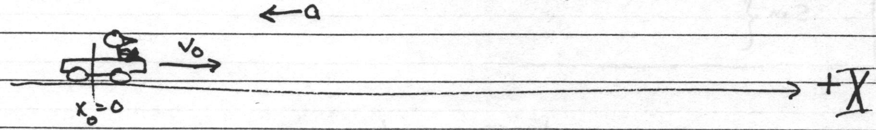


FIGURE 2–38 Problem 62.

86. Pelicans tuck their wings and free fall straight down when diving for fish. Suppose a pelican starts its dive from a height of 16.0 m and cannot change its path once committed. If it takes a fish 0.20 s to perform evasive action, at what minimum height must it spot the pelican to escape? Assume the fish is at the surface of the water.

2.42 Auto Airbags



$v(t) = v_0 + at$ $\qquad$ $x(t) = x_0 + v_0 t + \frac{1}{2}at^2$

$$v_0 = 96 \frac{km}{h} = 96 \frac{1000\ m}{3600\ s} = 26.67\ m/s$$
$$a = -250\ m/s^2$$
let $x_0 = 0$

Eventually want to know total distance travelled, but for now we can easily calculate the time it takes to stop

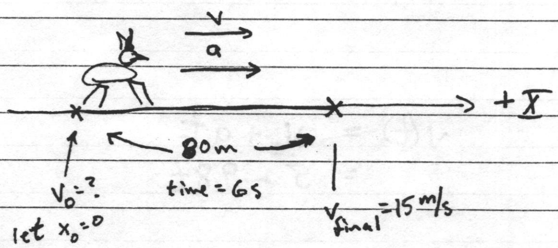
$$v(t) = v_0 + at$$
$$0 = 26.67 + (-250)t$$
$$t = 0.11\ sec$$

To find distance travelled

$$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$$
$$x = 0 + 26.67(0.11) + \frac{1}{2}(-250)(0.11)^2$$
$$= 1.42\ m$$
$$= 4.7\ ft$$

1 ft = 30.48 cm

2.15



$v(t) = v_0 + at$ $\qquad$ $x(t) = x_0 + v_0 t + \frac{1}{2}at^2$

$15 = v_0 + a6$ $\qquad$ $80 = 0 + v_0 6 + \frac{1}{2} a 6^2$

$80 = 6v_0 + 18a$

2 eqns - 2 unknowns

$15 - 6a = v_0$

$80 = 6(15 - 6a) + 18a$

$80 = 90 - 36a + 18a$

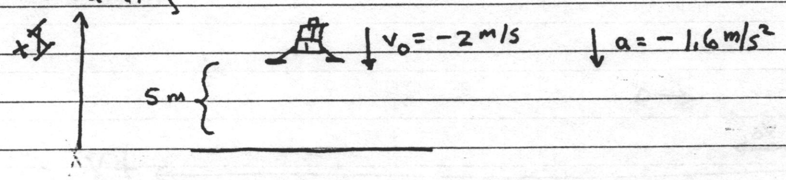
$-10 = -18a$

$a = 0.56\ m/s^2$

$15 - 6(\ \ ) = v_0$

$v_0 = 11.7\ m/s$

2.22 Moon Landing



Find speed when it hits.

$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$

$= 5 - 2t + \frac{1}{2}(-1.6)t^2$

$= 5 - 2t - 0.8t^2$

$v(t) = v_0 + at$

$= -2 - 1.6t$

Hits ground when $x(t) = 0$

$0 = 5 - 2t - 0.8t^2$

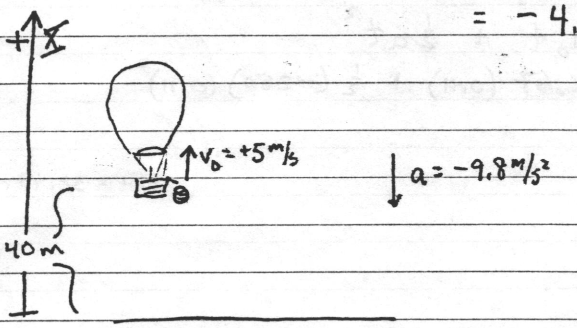
$t = \frac{2 \pm \sqrt{4 - 4(-0.8)5}}{2(-0.8)} = \frac{2 \pm \sqrt{20}}{-1.6} = \cancel{-4.1}, \ 1.55 \text{ sec}$

Velocity

$v(t) = -2 - 1.6(1.55)$

$= -4.5 \ m/s \longrightarrow \text{speed} = 4.5\,m/s$

2.28



$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$

$= 40 + 5t + \frac{1}{2}(-9.8)t^2$

$= 40 + 5t - 4.9t^2$

$v(t) = v_0 + at$

$= 5 - 9.8t$

a) At $t = 0.5\,s$ $\quad x(t) = 40 + 5(0.5) - 4.9(0.5)^2 = 41.3 \ m$ $\quad v(t) = 5 - 9.8(0.5) = +0.1 \ m/s$

At $t = 2\,s$ $\quad x(t) = 40 + 5(2) - 4.9(2)^2 = 30.4 \ m$ $\quad v(t) = 5 - 9.8(2) = -14.6\,m/s$

b) On ground when $x(t) = 0$ $\quad 0 = 40 + 5t - 4.9t^2$

$t = \frac{-5 \pm \sqrt{25 - 4(-4.9)40}}{2(-4.9)}$

$= \frac{-5 \pm 28.4}{-9.8}$

$= 3.4, \ \cancel{-2.4} \text{ sec}$

c) Speed $\quad v(t) = 5 - 9.8t = 5 - 9.8(3.4)$

$= -28.3 \ m/s \longrightarrow \text{speed} = 28.3\,m/s$

100.

36. 75 m

$v_{x_f}^2 - v_{x_i}^2 = 2 a_x \Delta x$

$0^2 - v_{x_i}^2 = 2(-7)75$

$v_{x_i} = 32.4$ m/s

~ 73 mph

38. 95 km/h

0.8 m

$v_{x_f}^2 - v_{x_i}^2 = 2 a_x \Delta x$

$v_{x_i} = 95 \frac{km}{hr} = 95 \frac{10^3}{3600}$ m/s

$= 26.39$ m/s

$0^2 - (26.39)^2 = 2 a_x (0.8\,m)$

$a_x = -435$ m/s^2

$= 44$ g's

71. 100 km/h

$v_{x_f}^2 - v_{x_i}^2 = 2 a_x \Delta x$

$a_x = -30(9.8) = -294$

$v_{x_i} = 100 \frac{km}{h} = 100 \frac{10^3}{3600} \frac{m}{s} = 27.78$ m/s

$0^2 - (27.78)^2 = 2(-294)\Delta x$

$\Delta x = 1.31$ m

37. 55 km/h

0.5 m/s^2

$x(t) = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$

$v_x(t) = v_0 + a_x t$

$x_0 = 0$

$v_{0x} = 55 \frac{km}{h} = \frac{55 \cdot 10^3\,m}{3600\,s} = 15.28$ m/s

$a = -0.5$

b) Time to stop

$v = 15.28 + (-0.5)t$

$0 = \quad t = 30.56$ s

a) $x(t) = 0 + 15.28 t + \frac{1}{2}(-0.5)t^2$

466.96 − 233.48

= 233. m

c)	$t=0$	0	> 15 m
1 (	$t=1$	15.03	
2 (	$t=2$		
3 (	$t=3$		
4 (	$t=4$	57.12	> 13 m
5 (	$t=5$	70.15	

67. terminal vel

$a = \frac{dv}{dt} = g - kv$

$u = g - kv$

$du = -k\,dv$

$dv = (g - kv)\,dt$

$-\frac{1}{k} du = u\,dt$

$\frac{du}{u} = -\frac{1}{k} dt$

$\ln u = -\frac{1}{k} t + \text{const}$

$u = e^{-t/k + \text{const}}$

$g - kv = C e^{-t/k}$

$v = -\frac{C}{k} e^{-t/k} + \frac{g}{k}$

If at $t=0$ $v=0$

then need to pick $C = g$

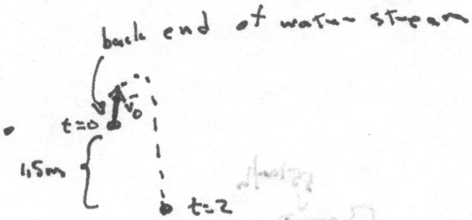
$v(t) = \frac{g}{k}(1 - e^{-t/k})$

Max velocity is

$v_{max} = \frac{g}{k}$

~~88.~~

62.



$y(t) = y_0 + v_{0y} t + \frac{1}{2} a_y t^2$

$v_y(t) = v_{0y} + a_y t$

$y_0 = 1.5$

$v_{0y} = ?$

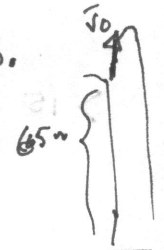
$a_y = -9.8 \ m/s^2$

$\underset{0}{y(t)} = 1.5 + v_{0y} \underset{2}{t} + \frac{1}{2}(-9.8)\underset{2}{t}^2$

$0 = 1.5 + v_{0y} 2 - 19.6$

$v_{0y} = 9.05 \ m/s$

83.



$y(t) = y_0 + v_{0y} t + \frac{1}{2} a_y t^2$

$v_y(t) = v_{0y} + a_y t$

$y_0 = 65$

$v_{0y} = +10$

$a_y = -9.8$

$y(t) = 65 + 10t + \frac{1}{2}(-9.8)t^2 \qquad v_y(t) = 10 - 9.8t$

a) time to bottom

$0 = 65 + 10t - 4.9t^2$

$t = \frac{-10 \pm \sqrt{10^2 - 4(-4.9)(65)}}{+2(-4.9)}$

$= \frac{-10 \pm 37}{-9.8}$

$= 4.8 \ s, \ -2.76 \ s$

b) speed at bottom

$v_y(t) = 10 - 9.8(4.8)$

$= -37 \ m/s$

$|\vec{v}| = v = 37 \ m/s$

86.

fish must start to move 0.2 s before pelican hits water

$y(t) = y_0 + v_{0y} t + \frac{1}{2} a_y t^2$

$v_y(t) = v_{0y} + a_y t$

$y_0 = 16$

$v_{0y} = 0$

$a_y = -9.8$

$y(t) = 16 + \frac{1}{2}(-9.8)t^2 \qquad v_y(t) = -9.8t$

Pelican hits water at time

$0 = 16 + \frac{1}{2}(-9.8)t^2$

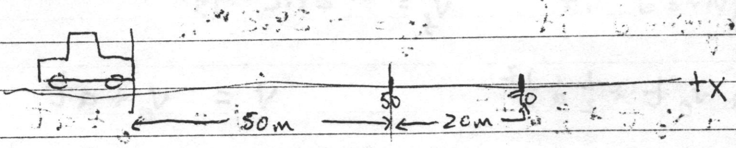
$t = 1.81 \ sec$

where is Pelican 0.2 s earlier?

$y = 16 + \frac{1}{2}(-9.8)(1.61)^2$

$= 3.3 \ m$

2.45.



slows down

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

$v_0 = 20$ m/s

$x_0 = 0$

$a = -4.2$ m/s

$$= 20t + \tfrac{1}{2}(-4.2)t^2$$

speeds up

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

$x_0 = 0$

$v_0 = 20$ m/s

$a = 1.5$ m/s

$$= 20t + \tfrac{1}{2}(1.5)t^2$$

After the yellow light $t = 3$ s

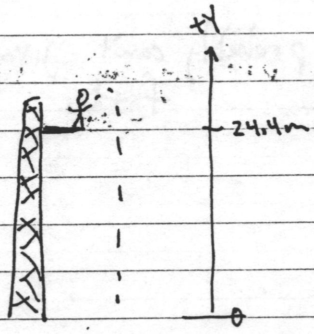
$$x = 0 + 20(3) + \tfrac{1}{2}(-4.2)(3)^2 = 41.1 \text{ m}$$

$$x = 0 + 20(3) + \tfrac{1}{2}(1.5)(3)^2 = 66.7 \text{ m}$$

Car will get stopped before intersection.

Car will be in the intersection during red

2.53.



~~claim~~

$$y(t) = y_0 + v_0 t + \tfrac{1}{2} a t^2 \qquad v(t) = v_0 + at$$

$y_0 = 24.4$ m

$v_0 = 0$

$a = 9.8$ m/s² down $= -9.8$ m/s²

$$y = 24.4 + \tfrac{1}{2}(-9.8)t^2 \qquad v = -9.8t$$

a) speed when hit water ; need time

– know hits water when $y = 0 = 24.4 + \tfrac{1}{2}(-9.8)t^2$

$\rightarrow t = 2.23$ sec

$$v = -9.8(2.23) = 21.8 \text{ m/s}$$

the claim was $65 \frac{mi}{hr} = 105 \frac{km}{hr} = 105 \frac{1000 \text{ m}}{3600 \text{ s}} = 29.2$ m/s

→ Not quite as fast as claimed.

b)

— over —

b) What v_0 required if $v_f = -29.2\ m/s$

$$y(t) = y_0 + v_0 t + \frac{1}{2} a t^2 \qquad v = v_0 + at$$

$y_0 = 24.4$
$v_0 = ?$
$a = -9.8$

And want $v = -29.2$ at $y = 0$

$$0 = 24.4 + v_0 t + \frac{1}{2}(-9.8)t^2 \qquad -29.2 = v_0 - 9.8t$$

2 eqn, 2 unknowns

$$t = \frac{1}{9.8}(v_0 + 29.2)$$

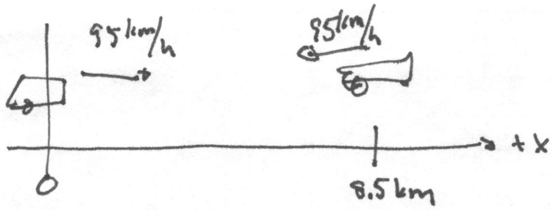
$$0 = 24.4 + v_0 \frac{1}{9.8}(v_0 + 29.2) - 4.9\left(\frac{1}{9.8}\right)^2 (v_0 + 29.2)^2$$

$\vdots$

$$v_0 = \pm 19.3\ m/s \longrightarrow \sim 43\ \frac{mi}{hr}$$

- probably can't jump this fast

class 10.



$x(t) = x_0 + v_{ox}t + \frac{1}{2}a_x t^2$

$x_0 = 0$

$v_{ox} = +95 \frac{km}{h} = 95 \frac{10^3}{3600}\frac{m}{s}$

$= 26.39 \, m/s$

$a_x = 0$

$X(t) = X_0 + V_{ox}t + \frac{1}{2}A_x t^2$

$X_0 = 8.5 \, km = 8500 \, m$

$V_{ox} = -95 \frac{km}{h} = -26.39 \, m/s$

$A_x = 0$

$x(t) = 26.39t$ $\quad X(t) = 8500 - 26.39t$

they meet when positions are the same

$x(t) = X(t)$

$26.39t = 8500 - 26.39t$

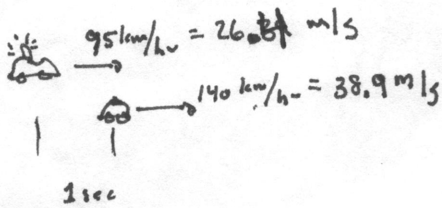
$t = 161 \text{ sec}$

where's this at?

$x(t) = 26.39(161)$

$= 4250 \, m$

HW 44.



$x(t) = x_0 + v_{ox}t + \frac{1}{2}a_x t^2$

$x_0 = 0$

$v_{ox} = 26.4$

$a_x = 2$

$X(t) = X_0 + V_{ox}t + \frac{1}{2}A_x t^2$

$X_0 = 38.9 \, m$

$V_{ox} = 38.9 \, m/s$

$A_x = 0$

$x(t) = 26.4t + \frac{1}{2}(2)t^2$ $\quad X(t) = 38.9 + 38.9t$

meet when $x = X$

$26.4t + t^2 = 38.9 + 38.9t$

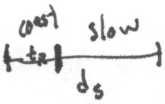
$\cancel{-38.9(1+t)}$

$t^2 - 12.5t - 38.9 = 0$

$t = \frac{12.5 \pm \sqrt{12.5^2 - 4(1)(-38.9)}}{2(1)}$

$= \frac{12.5 \pm 17.6}{2} = \cancel{-2.55}, \; 15.1 \, s$

42.



$x = x_0 + v_{ox}t + \frac{1}{2}a_x t^2$

coasting distance

$x_c = v_{ox}t_R$

slowing dist

$v_f^2 - v_i^2 = 2a_x \Delta x$

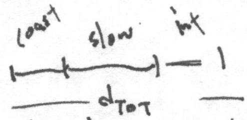
$0^2 - v_{ox}^2 = 2a_x \Delta x$

$\Delta x = -\frac{v_{ox}^2}{2a_x}$

so

$d_s = v_0 t_R - \frac{v_{ox}^2}{2a}$

43.



time to drive right on through / at const speed would be

$t = \frac{d_{coast} + d_{slow} + d_{int}}{V_0}$

$V_0 t = d_{coast} + d_{slow} + d_{int}$

$= V_0 t_R - \frac{V_0^2}{2a} + d_{int}$

$t = t_R - \frac{V_0}{2a} + \frac{d_{int}}{V_0}$

case 1

$t_R = 0.5$

$V_0 = 30 \frac{km}{h} = 8.33$

$a_x = -4 \, m/s^2$

$0.5 - \frac{8.33}{2(-4)} + \frac{14.4}{8.33}$

3.27 s

case 2

$t_R = 0.5$

$V_0 = 60 \frac{km}{h} = 16.67$

$a_x = -4 \, m/s^2$

$0.5 - \frac{16.66}{2(-4)} + \frac{14.4}{16.67}$

3.45 s

choose