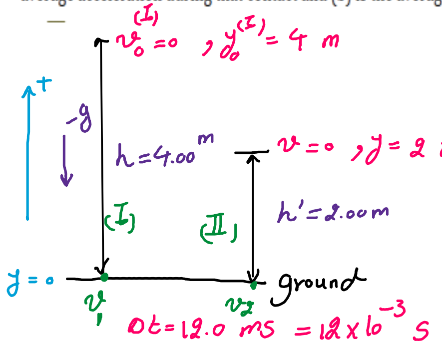
57 M To test the quality of a tennis ball, you drop it onto the floor from a height of 4.00 m. It rebounds to a height of 2.00 m. If the ball is in contact with the floor for 12.0 ms, (a) what is the magnitude of its average acceleration during that contact and (b) is the average acceleration up or down?



$$a = \frac{\Delta v}{\Delta t}$$

(I) : $v_1^2 - \cancel{v_0^{(I)2}} = -2g(\cancel{y_1} - y_0)$

$\Rightarrow v_1^2 = -2\times9.8\times(0-4) = 78.4$

$\Rightarrow v_1 = \mp\sqrt{78.4} \Rightarrow v_1 = -8.85$ m/s

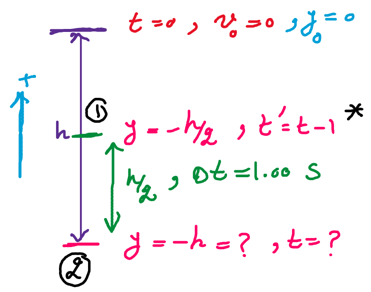
(II) : $\cancel{v^2} - \underbrace{v_0^2}_{v_2^2} = -2g(y - \cancel{y_0})$ $\Rightarrow -v_2^2 = -2\times9.8\times2 \Rightarrow v_2^2 = 39.2$

$\Rightarrow v_2 = \mp\sqrt{39.2} \Rightarrow v_2 = 6.26$ m/s

$$a = \frac{v_2 - v_1}{\Delta t} = \frac{6.26-(-8.85)}{12\times10^{-3}} \simeq 1259.1 = 1.26\times10^{3} \text{ m/s}^2$$

b) up

58 M An object falls a distance h from rest. If it travels $0.50h$ in the last 1.00 s, find (a) the time and (b) the height of its fall. (c) Explain the physically unacceptable solution of the quadratic equation in t that you obtain.



a) $y = -\frac12 g t^2 + v_0 t + y_0$

① : $-h/2 = -\frac12 g t'^2 + 0 + 0 \Rightarrow t'^2 = \frac{h}{g}$

② : $-h = -\frac12 g t^2 + 0 + 0 \Rightarrow t^2 = \frac{2h}{g}$ (I)

$\xRightarrow{\div} \frac{t'^2}{t^2} = \frac12$

$\Rightarrow \frac{t'}{t} = \mp\frac{1}{\sqrt2} \Rightarrow t' = \frac{t}{\sqrt2}$ *'

* : $t' = t-1 \xRightarrow{*'} \frac{t}{\sqrt2} = t-1 \Rightarrow t - \frac{t}{\sqrt2} = 1 \Rightarrow t\left(1-\frac{1}{\sqrt2}\right) = 1 \Rightarrow t = \frac{1}{1-\frac{1}{\sqrt2}}$

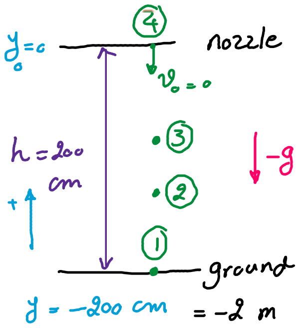
$\Rightarrow t = 3.41$ s

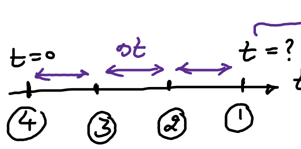
b) (I) : $h = \frac12\times9.8\times(3.41)^2 \simeq 56.97 \simeq 57.0$ m

c) $t' = -\frac{t}{\sqrt2} \xRightarrow{*} \frac{-t}{\sqrt2} = t-1 \Rightarrow t + \frac{t}{\sqrt2} = 1 \Rightarrow t\left(1+\frac{1}{\sqrt2}\right) = 1 \Rightarrow t = \frac{1}{1+\frac{1}{\sqrt2}}$

$\Rightarrow t \simeq 0.59$ s $\Rightarrow t' = \frac{-0.59}{\sqrt2}$: unacceptable

59 M Water drips from the nozzle of a shower onto the floor 200 cm below. The drops fall at regular (equal) intervals of time, the first drop striking the floor at the instant the fourth drop begins to fall. When the first drop strikes the floor, how far below the nozzle are the (a) second and (b) third drops?





$\longrightarrow \Delta t = \dfrac{0.639}{3} = 0.231\ s$

$* \quad y = -\frac{1}{2}gt^2 + \cancel{v_0 t}^{\,0} + \cancel{y_0}^{\,0}$

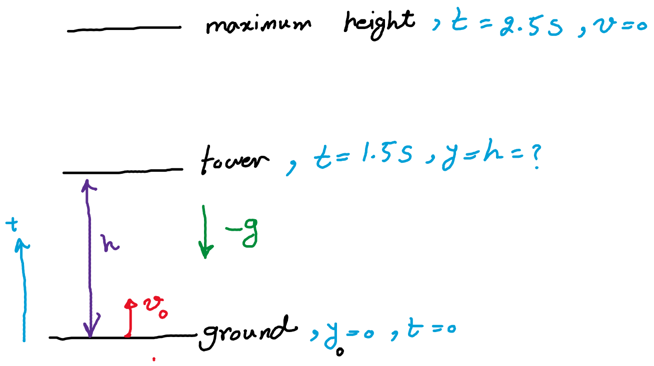
$\longrightarrow y_1 = -\frac{1}{2}g t_1^2 \longrightarrow -2 = -\frac{1}{2}\times 9.8\, t_1^2 \longrightarrow t_1^2 = \dfrac{4}{9.8}$

$t_1 \simeq 0.639\ s$

a) $t_2 = 2\times 0.231 = 0.462\ s \xrightarrow{*} y_2 = -\frac{1}{2}\times 9.8\times(0.462)^2 \simeq -0.889\ m \simeq -89\ cm$

b) $t_3 = 0.231\ s \xrightarrow{*} y_3 = -\frac{1}{2}\times 9.8\times(0.231)^2 \simeq -0.222\ m \simeq -22\ cm$

60 M GO A rock is thrown vertically upward from ground level at time $t = 0$. At $t = 1.5$ s it passes the top of a tall tower, and 1.0 s later it reaches its maximum height. What is the height of the tower?



$y = -\frac{1}{2}gt^2 + v_0 t + y_0$

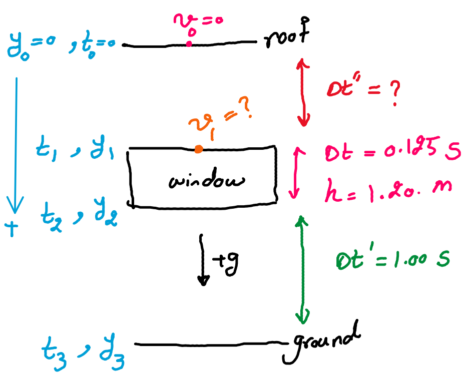
$v = -gt + v_0$

$0 = -9.8\times 2.5 + v_0 \longrightarrow v_0 \simeq 24.5\ s$

$\longrightarrow h = -\frac{1}{2}\times 9.8\times(1.5)^2 + 24.5\times 1.5 + 0$

$\longrightarrow h \simeq 25.725 \simeq 26\ m$

61 H GO A steel ball is dropped from a building's roof and passes a window, taking 0.125 s to fall from the top to the bottom of the window, a distance of 1.20 m. It then falls to a sidewalk and bounces back past the window, moving from bottom to top in 0.125 s. Assume that the upward flight is an exact reverse of the fall. The time the ball spends below the bottom of the window is 2.00 s. How tall is the building?



$y = \frac{1}{2}at^2 + v_0 t + y_0$

$y_f = \frac{1}{2}a(t_f - t_i)^2 + v_i(t_f - t_i) + y_i \quad *$

$\longrightarrow y_2 = \frac{1}{2}g(t_2 - t_1)^2 + v_1(t_2 - t_1) + y_1$

$\Delta t = t_2 - t_1, \quad h = y_2 - y_1$

$\longrightarrow y_2 - y_1 = h = \frac{1}{2}g(\Delta t)^2 + v_1 \Delta t$

$\longrightarrow 1.20 = \frac{1}{2}\times 9.8\times(0.125)^2 + v_1\times 0.125 \longrightarrow v_1 \simeq 8.987\ m/s$

$a = \dfrac{\Delta v}{\Delta t} \longrightarrow g = \dfrac{v_1 - v_0}{\underbrace{t_1 - t_0}_{=\Delta t''}} \longrightarrow 9.8 = \dfrac{8.987 - 0}{\Delta t''} \longrightarrow \Delta t'' \simeq 0.917\ s$

$\longrightarrow t_3 = \Delta t'' + \Delta t + \Delta t' = 0.917 + 0.125 + 1.00 \simeq 2.04\ s$

$* : y_3 = \frac{1}{2}g(t_3 - \cancel{t_0}^{\,0})^2 + \cancel{v_0}^{\,0}(t_3 - \cancel{t_0}^{\,0}) + \cancel{y_0}^{\,0} \longrightarrow y_3 = \frac{1}{2}\times 9.8\times(2.04)^2 \simeq 20.4\ m$