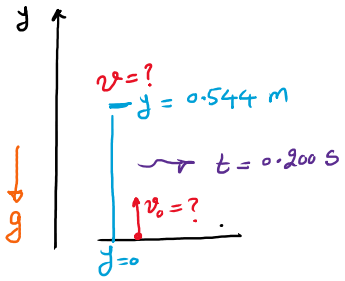
44 E When startled, an armadillo will leap upward. Suppose it rises 0.544 m in the first 0.200 s. (a) What is its initial speed as it leaves the ground? (b) What is its speed at the height of 0.544 m? (c) How much higher does it go?

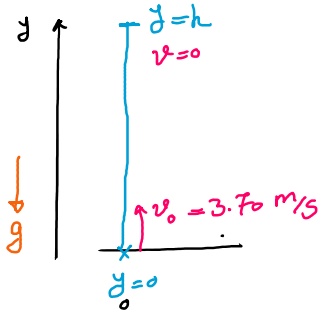


a) $y = \frac{1}{2}gt^2 + v_0 t + y_0$ ($y_0 = 0$)

$0.544 = \frac{1}{2} \times (-9.8) \times (0.2)^2 + v_0 \times 0.2$

$\Rightarrow v_0 = \frac{0.544 + 4.9 \times (0.2)^2}{0.2} = 3.70$ m/s

b) $a = \frac{\Delta v}{\Delta t} \Rightarrow -g = \frac{v - v_0}{t} \Rightarrow -9.8 = \frac{v - 3.7}{0.2} \Rightarrow v = -9.8 \times 0.2 + 3.7 = 1.74$ m/s



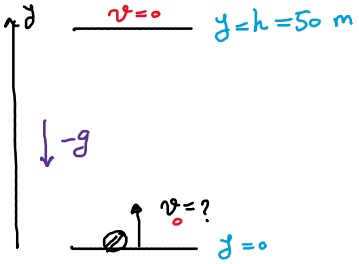
c) $v^2 - v_0^2 = 2a\Delta y$

$0 - (3.70)^2 = 2 \times (-9.8) \times h$

$\Rightarrow h = \frac{-(3.70)^2}{-2 \times 9.8} \simeq 0.698$ m

$\Rightarrow \Delta h = 0.698 - 0.544 = 0.154$ m

45 E SSM (a) With what speed must a ball be thrown vertically from ground level to rise to a maximum height of 50 m? (b) How long will it be in the air? (c) Sketch graphs of *y*, *v*, and *a* versus *t* for the ball. On the first two graphs, indicate the time at which 50 m is reached.



a) $v^2 - v_0^2 = -2g\Delta y$

$0 - v_0^2 = -2 \times 9.8 \times 50 \Rightarrow v_0 = \sqrt{2 \times 9.8 \times 50} \simeq 31.3$ m/s

b) $a = \frac{v - v_0}{t - t_0} \Rightarrow t = \frac{0 - 31.3}{-9.8} \simeq 3.19$ s ($t_0 = 0$)

$\Rightarrow T = 2t = 6.39$ s

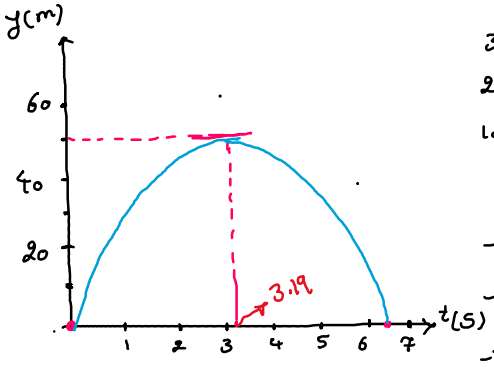
c) $y = \frac{1}{2}(-g)t^2 + v_0 t + y_0$

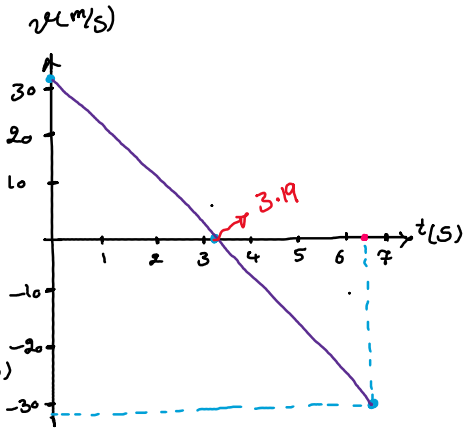
$y = -\frac{1}{2} \times 9.8\, t^2 + 31.3\, t$

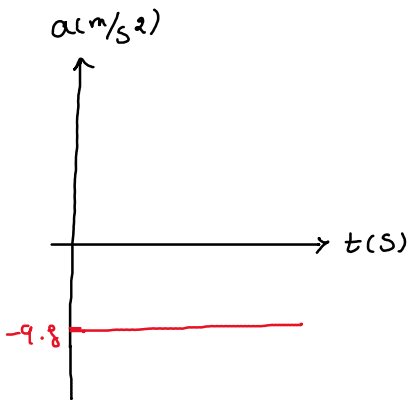
$y = -4.9t^2 + 31.3\, t$

$v = \frac{dy}{dt} = -9.8t + 31.3$

$a = -9.8$ m/s²







46 E Raindrops fall 1700 m from a cloud to the ground. (a) If they were not slowed by air resistance, how fast would the drops be moving when they struck the ground? (b) Would it be safe to walk outside during a rainstorm?

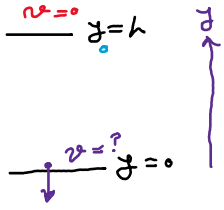
$h = 1700\ m$

$v_0 = 0$

$a = -g$

$v^2 - v_0^2 = -2g\,\Delta y \rightsquigarrow y - y_0 = 0 - h$

$v^2 - 0 = -2 \times 9.9 \times (-1700) \rightarrow v = -183\ m/s$

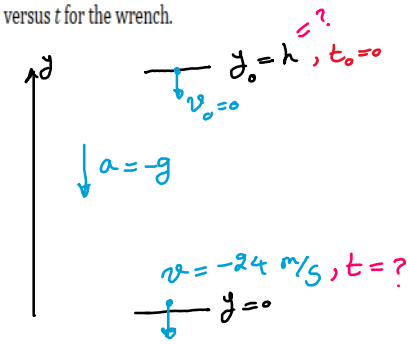


b)

$F \rightsquigarrow$ air resistance

$\rightarrow \sum F = mg - F = ma \rightarrow a = \frac{mg - F}{m} = g - \frac{F}{m} < g$

47 E SSM At a construction site a pipe wrench struck the ground with a speed of 24 m/s. (a) From what height was it inadvertently dropped? (b) How long was it falling? (c) Sketch graphs of y, v, and a versus t for the wrench.



a) $v^2 - v_0^2 = -2g\,\Delta y$

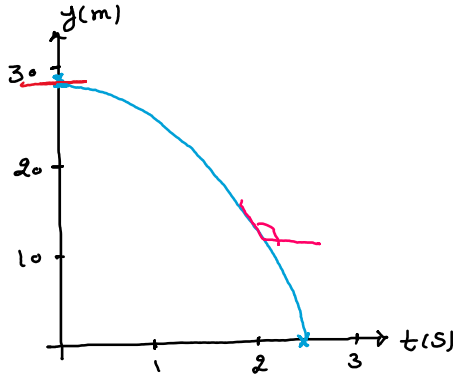
$y - y_0 = 0 - h$

$\rightarrow (-24)^2 - 0 = -2 \times 9.8 \times (-h) \rightarrow h = \frac{24^2}{2 \times 9.8} \simeq 29.4\ m$

b) $a = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{t - t_0}$ ($v_0 = 0$, $t_0 = 0$) $\rightarrow t = \frac{-24}{-9.8} \simeq 2.45\ s$

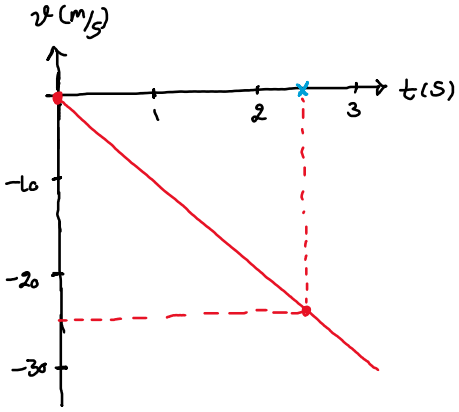
c) $y = -\frac{1}{2} g t^2 + v_0 t + y_0 = h$ ($v_0 = 0$)

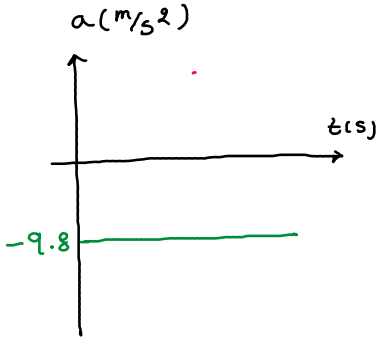
$y = -4.9\,t^2 + 29.4$



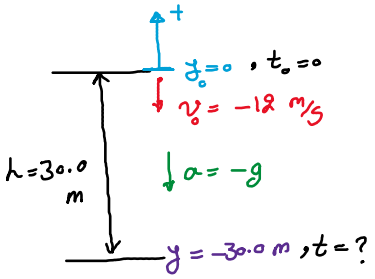
$v = \frac{dy}{dt} = -9.8t$

$a = \frac{dv}{dt} = -9.8\ m/s^2$





48 E A hoodlum throws a stone vertically downward with an initial speed of 12.0 m/s from the roof of a building, 30.0 m above the ground. (a) How long does it take the stone to reach the ground? (b) What is the speed of the stone at impact?



a) $y=-\frac{1}{2}gt^2+v_0t+y_0$

$-30=-\frac{1}{2}\times 9.8t^2-12t+0$

$\Rightarrow 4.9t^2+12t-30=0$

$a=4.9$, $b=6$, $c=-30$

$ax^2+2bx+c=0$

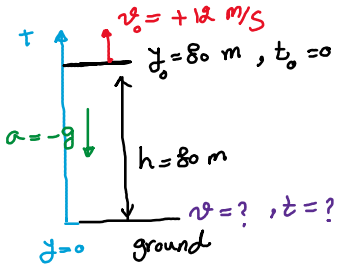
$x=\frac{-b\mp\sqrt{b^2-ac}}{a}$

$\Rightarrow t=\frac{-6\mp\sqrt{36+30\times4.9}}{4.9}=1.83$ $\Rightarrow$ $\ominus$: unacceptable

$\oplus$: $t\simeq 1.54$ s

b) $v=-gt+v_0 \Rightarrow v=-9.8\times1.54-12\simeq -27.1$ m/s $\Rightarrow$ speed $=27.1$ m/s

49 E SSM A hot-air balloon is ascending at the rate of 12 m/s and is 80 m above the ground when a package is dropped over the side. (a) How long does the package take to reach the ground? (b) With what speed does it hit the ground?



a) $y=-\frac{1}{2}gt^2+v_0t+y_0$

$0=-\frac{1}{2}\times9.8t^2+12t+80$

$\Rightarrow 4.9t^2-12t-80=0$

$a=4.9$, $b=-6$, $c=-80$

$ax^2+2bx+c=0$

$x=\frac{-b\mp\sqrt{b^2-ac}}{a}$

$\Rightarrow t=\frac{6\mp\sqrt{36+80\times4.9}}{4.9}$ $\Rightarrow$ $\ominus$: unacceptable

$\oplus$: $t\simeq 5.45$ s

b) $v=-gt+v_0=-9.8\times5.45+12\simeq -41.38$ m/s $\Rightarrow$ speed $\simeq 41.4$ m/s