3.11

According to the problem statement the speed of the runner changes from $v_i = 4.0\,\mathrm{m/s}$ to $v_f = 0$ in a time interval of $\Delta t = 0.50\,\mathrm{s}$. Thus her average acceleration is

$$a_{av} = \frac{v_f - v_i}{\Delta t} = \frac{0 - 4.0\,\mathrm{m/s}}{0.50\,\mathrm{s}} = -8.0\,\mathrm{m/s^2}\,,$$

where the minus sign indicates that she is decelerating. At $t = 0.30\,\mathrm{s}$ into the slide her speed is then

$$v = v_i + at = 4.0\,\mathrm{m/s} + (-8.0\,\mathrm{m/s^2})(0.30\,\mathrm{s}) = 1.6\,\mathrm{m/s}\,.$$

3.13

Let the time interval of each step be Δt. Then during the first step

$$a_{av} = \frac{3.0\,\mathrm{m/s} - 0}{\Delta t} = \frac{3.0\,\mathrm{m/s}}{\Delta t}\,;$$

during the second step

$$a_{av} = \frac{4.2\,\mathrm{m/s} - 3.0\,\mathrm{m/s}}{\Delta t} = \frac{1.2\,\mathrm{m/s}}{\Delta t}\,;$$

and during the third step

$$a_{av} = \frac{5.0\,\mathrm{m/s} - 4.2\,\mathrm{m/s}}{\Delta t} = \frac{0.8\,\mathrm{m/s}}{\Delta t}\,.$$

This tells us that, although his speed increases with every step, his acceleration is decreasing.

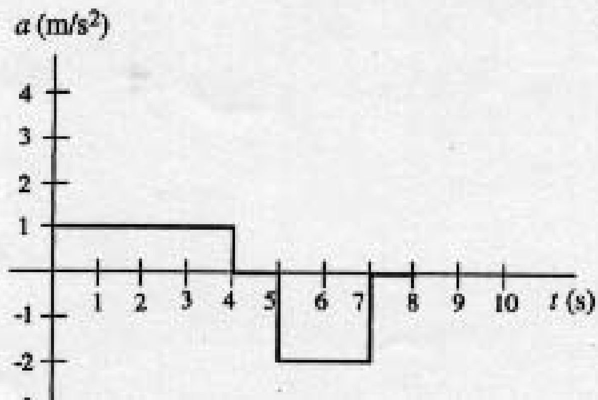
3.15

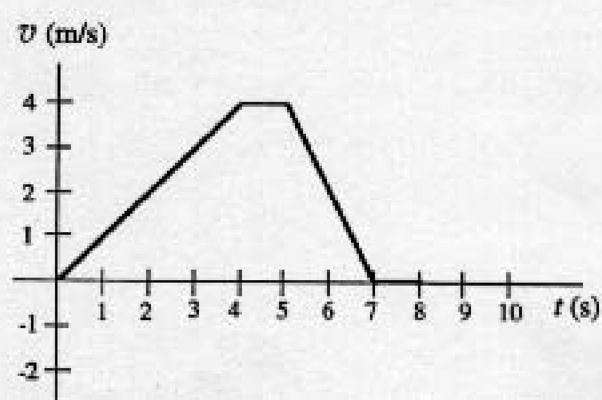
The change in speed for the train is given by $\Delta v = 0 - 60\,\mathrm{km/h} = -60\,\mathrm{km/h}$, while the time interval is $\Delta t = (1/1000)\,\mathrm{s}$. Thus the deceleration of the train is

$$a = \frac{\Delta v}{\Delta t} = \frac{(-60\,\mathrm{km/h})(1\,\mathrm{h}/3600\,\mathrm{s})}{(1/1000)\,\mathrm{s}} = -17\,\mathrm{km/s^2}\,,$$

3.32

According to the problem statement $a = 1\,\mathrm{m/s^2}$ from $t = 0$ to $4\,\mathrm{s}$, $a = 0$ from $t = 4\,\mathrm{s}$ to $5\,\mathrm{s}$, and then $a = -2\,\mathrm{m/s^2}$ from $t = 5\,\mathrm{s}$ to $7\,\mathrm{s}$. The corresponding a vs t diagram is shown below on the left. For the v vs t diagram, use $v = v_0 + a(t - t_0)$ to compute the speed as a function of time during each stage of constant acceleration. For example, the speed at $t = 4\,\mathrm{s}$ is given by $v = 0 + (1\,\mathrm{m/s^2})(4\,\mathrm{s}) = 4\,\mathrm{m/s}$. Draw a straight line connecting $v_0 = 0$, $t_0 = 0$ and $v = 4\,\mathrm{m/s}$, $t = 4\,\mathrm{s}$ to obtain the v vs t diagram for that time duration. The diagram from $t = 4.0\,\mathrm{s}$ on can be obtained in a similar fashion. The complete v vs t diagram is shown below on the right.





3.58
The Corvette's initial speed before decelerating is $v_0 = 60\,\text{mi/h} = 26.8\,\text{m/s}$, and its final speed after traversing a distance of $l = 35.4\,\text{m}$ is $v = 0$. From Eq. (3.13), $v^2 = v_0^2 + 2a_t l$, we solve for a:

$$a_t = \frac{v^2 - v_0^2}{2l} = \frac{0 - (26.8\,\text{m/s})^2}{2(35.4\,\text{m})} = -10.1\,\text{m/s}^2\,,$$

where the minus sign indicates that the speed is decreasing.

3.68
The initial speed of the supertanker before it starts to decelerate is $v_0 = 30\,\text{km/h}$. After decelerating for $t = 20\,\text{min}$, its final speed is $v = 0$. From $v = v_0 + at$ [Eq. (3.6)] we may solve for a:

$$a = \frac{v - v_0}{t} = \frac{0 - (30\,\text{km/h})(10^3\,\text{m/km})(1\,\text{h}/3600\,\text{s})}{(20\,\text{min})(60\,\text{s/min})} = -6.9 \times 10^{-3}\,\text{m/s}^2\,,$$

where the minus sign indicates that the supertanker is decelerating. The stopping distance s can now be obtained from $v^2 = v_0^2 + 2as$:

$$s = \frac{v^2 - v_0^2}{2a} = \frac{0 - \left[(30\,\text{km/h})(10^3\,\text{m/km})(1\,\text{h}/3600\,\text{s})\right]^2}{2(-6.9 \times 10^{-3}\,\text{m/s}^2)} = 5.0 \times 10^3\,\text{m} = 5.0\,\text{km}\,.$$

3.69
The initial speed of the bullet before it enters the block of clay is $v_0 = 300\,\text{m/s}$. After decelerating with an average deceleration of a_{av} over a distance of $s = 5\,\text{cm} = 0.05\,\text{m}$ its final speed is $v = 0$. From $v^2 = v_0^2 + 2a_{av}s$ we may solve for a_{av}:

$$a_{av} = \frac{v^2 - v_0^2}{2s} = \frac{0 - (300\,\text{m/s})^2}{2(0.05\,\text{m})} = -0.9 \times 10^6\,\text{m/s}^2\,,$$

where the minus sign indicates that the bullet is decelerating.

3.70
Apply Eq. (3.10): $v^2 = v_0^2 + 2as$. Here $v_0 = 30.0\,\text{m/s}$ is the speed of the car before the collision, $v = 0$ is its speed after the collision, and $s = 50.0\,\text{cm} = 0.500\,\text{m}$ is the distance traversed by the car during its deceleration. Solve for a:

$$a = \frac{v^2 - v_0^2}{2s} = \frac{0 - (30.0\,\text{m/s})^2}{2(0.500\,\text{m})} = -900\,\text{m/s}^2\,,$$

where the minus sign corresponds to the fact that the car is slowing down.

3.78
Since the two cars have the same initial speed ($= 0$) and acceleration ($= a$), they will collide after each covers a distance of $s = 100\,\text{m}/2 = 50.0\,\text{m}$. The time t it takes for either car to traverse that much distance satisfies $s = \frac{1}{2}at^2$. Solve for t:

$$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2(50.0\,\text{m})}{2.5\,\text{m/s}^2}} = 6.3\,\text{s}\,.$$

Thus at the moment of the impact the clock will read 12:17:00 + 6.3 s = 12:17:06.

3.81

In Problem (3.73) we derived an expression for the displacement s as a function of the reaction time t_R. In our notation for this problem $s \to s_S$, so

$$s_S = v_0 t_R - \frac{v_0^2}{2a}.$$

Plug in $a = -6.9\,\mathrm{m/s^2}$, and $t_R = 0.6\,\mathrm{s}$ to obtain

$$s_S = v_0 t_R - \frac{v_0^2}{2a} = (0.6\,\mathrm{s})v_0 - \frac{(9.72\,\mathrm{m/s})^2}{2(-6.9\,\mathrm{m/s^2})} = (0.6\,\mathrm{s})v_0 + (0.07\,\mathrm{s^2/m})v_0^2.$$

For $v_0 = 35\,\mathrm{km/h} = (35\,\mathrm{km/h})(10^3\,\mathrm{m/km})(1\,\mathrm{h}/3600\,\mathrm{s}) = 9.72\,\mathrm{m/s}$, this is

$$s_S = (0.6\,\mathrm{s})(9.72\,\mathrm{m/s}) + (0.07\,\mathrm{s^2/m})(9.72\,\mathrm{m/s})^2 = 0.1 \times 10^2\,\mathrm{m}.$$

3.94

Use Eq. (3.18) for the peak altitude: $s_p = -v_0^2/2g$. Solve for v_0:

$$v_0 = \sqrt{-2s_p g} = \sqrt{-2(2.5\,\mathrm{m})(-9.81\,\mathrm{m/s^2})} = 7.0\,\mathrm{m/s}.$$

3.103

The displacement s of the baseball in free fall as a function of time t is given by $s = v_0 t + \frac{1}{2}gt^2$. Since the ball returns to the boy's hand, its net displacement is $s = 0$, so $v_0 t + \frac{1}{2}gt^2 = 0$. Take the upward direction to be positive and solve for the initial speed v_0:

$$v_0 = -\frac{1}{2}gt = -\frac{1}{2}(-9.8\,\mathrm{m/s^2})(1.0\,\mathrm{s}) = 4.9\,\mathrm{m/s}.$$

3.111

Take the downward direction as positive. Let the initial speed of the bag as it passes the top of his head be v_0, then a time t $(= 0.20\,\mathrm{s})$ later as it hit the ground its speed becomes $v = v_0 + gt$. The average speed of the bag during time t is then $v_{av} = (v_0 + v)/2 = v_0 + \frac{1}{2}gt = v - \frac{1}{2}gt$. Let $s = +2\,\mathrm{m} = v_{av}t$ and solve for v:

$$v = \frac{s}{t} + \frac{1}{2}gt = \frac{2\,\mathrm{m}}{0.20\,\mathrm{s}} + \frac{1}{2}(9.81\,\mathrm{m/s^2})(0.20\,\mathrm{s}) = 10.98\,\mathrm{m/s}.$$

To reach this final speed, the bag must have fallen freely from a height s_B, where $v^2 = 2gs_B$. Thus the height of the building is

$$s_B = \frac{v^2}{2g} = \frac{(10.98\,\mathrm{m/s})^2}{2(9.81\,\mathrm{m/s^2})} = 6.14\,\mathrm{m} \approx 6\,\mathrm{m}.$$

(Note that the final answer has only one significant figure, since the height of the gangster is given by $s = 2\,\mathrm{m}$.)

3.115

Take the downward direction to be positive. Since the egg falls vertically for $t = 2.0\,\mathrm{s}$, its vertical displacement, which is equal in magnitude to the height of its launch point, is given by

$$s_y = \frac{1}{2}gt^2 = \frac{1}{2}(9.81\,\mathrm{m/s^2})(2.0\,\mathrm{s})^2 = 20\,\mathrm{m}.$$

Here we noted that, since the egg is projected out of the window horizontally, the vertical component of its initial velocity is zero.

3.121

In the vertical direction, each clown will fall by $s_y = 10\,\mathrm{m}$ to reach the surface of the pool. The time t it takes to fall freely through this much distance satisfies $s_y = \frac{1}{2}gt^2$, which gives the time of flight to be

$$t = \sqrt{\frac{2s_y}{g}} = \sqrt{\frac{2(10\,\mathrm{m})}{9.81\,\mathrm{m/s^2}}} = 1.428\,\mathrm{s}\,.$$

Meanwhile, each clown must also move horizontally by $s_x = \frac{1}{2}(30\,\mathrm{m}) = 15\,\mathrm{m}$ to meet in the middle of the pool. Thus their horizontal speed v_x must satisfy $s_x = v_x t$, or

$$v_x = \frac{s_x}{t} = \frac{15\,\mathrm{m}}{1.428\,\mathrm{s}} = 11\,\mathrm{m/s}\,.$$