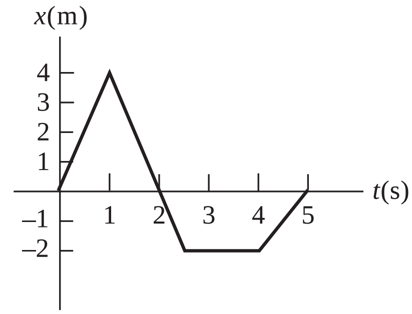
PHY 2130 Homework solutions
Assignment 2



2.7 (a) $v_{0,1} = \dfrac{x_1 - x_0}{\Delta t} = \dfrac{4.0\text{ m} - 0}{1.0\text{ s}} = \boxed{+4.0\text{ m/s}}$

(b) $v_{0,4} = \dfrac{x_4 - x_0}{\Delta t} = \dfrac{-2.0\text{ m} - 0}{4.0\text{ s}} = \boxed{-0.5\text{ m/s}}$

(c) $v_{1,5} = \dfrac{x_5 - x_1}{\Delta t} = \dfrac{0 - 4.0\text{ m}}{4.0\text{ s}} = \boxed{-1.0\text{ m/s}}$

(d) $v_{0,5} = \dfrac{x_5 - x_0}{\Delta t} = \dfrac{0 - 0}{5.0\text{ s}} = \boxed{0}$

2.8 (a) The time for a car to make the trip is $t = \dfrac{\Delta x}{v}$. Thus, the difference in the times for the two cars to complete the same 10 mile trip is

$$\Delta t = t_1 - t_2 = \frac{\Delta x}{v_1} - \frac{\Delta x}{v_2} = \left(\frac{10\text{ mi}}{55\text{ mi/h}} - \frac{10\text{ mi}}{70\text{ mi/h}}\right)\left(\frac{60\text{ min}}{1\text{ h}}\right) = \boxed{2.3\text{ min}}$$

(b) When the faster car has a 15.0 min lead, it is ahead by a distance equal to that traveled by the slower car in a time of 15.0 min. This distance is given by $\Delta x_1 = v_2(\Delta t) = (55\text{ mi/h})(15\text{ min})$.

The faster car pulls ahead of the slower car at a rate of: $v_{relative} = 70\text{ mi/h} - 55\text{ mi/h} = 15\text{ mi/h}$. Thus, the time required for it to get distance Δx_1 ahead is:

$$\Delta t = \frac{\Delta x_1}{v_{relative}} = \frac{(55\text{ mi/h})(15\text{ min})}{15.0\text{ mi/h}} = 55\text{ min}.$$

Finally, the distance the faster car has traveled during this time is

$$\Delta x = vt = (70\text{ mi/h})(55\text{ min})\left(\frac{1\text{ h}}{60\text{ min}}\right) = \boxed{64\text{ mi}}$$

2.21 From $a = \dfrac{\Delta v}{\Delta t}$, we have $\Delta t = \dfrac{\Delta v}{a} = \dfrac{(60 - 55)\text{ mi/h}}{0.60\text{ m/s}^2}\left(\dfrac{0.447\text{ m/s}}{1\text{ mi/h}}\right) = \boxed{3.7\text{ s}}$

2.28 (a) From the definition of acceleration, we have

$$a = \frac{v_f - v_i}{t} = \frac{0 - 40\ \text{m/s}}{5.0\ \text{s}} = \boxed{-8.0\ \text{m/s}^2}.$$

(b) From $\Delta x = v_i t + \frac{1}{2}at^2$, the displacement is

$$\Delta x = (40\ \text{m/s})(5.0\ \text{s}) + \frac{1}{2}(-8.0\ \text{m/s}^2)(5.0\ \text{s})^2 = \boxed{100\ \text{m}}.$$

2.43 (a) From $v_f^2 = v_i^2 + 2a(\Delta y)$ with $v_f = 0$, we have

$$(\Delta y)_{max} = \frac{v_f^2 - v_i^2}{2a} = \frac{0 - (25.0\ \text{m/s})^2}{2(-9.80\ \text{m/s}^2)} = \boxed{31.9\ \text{m}}.$$

(b) The time to reach the highest point is

$$t_{up} = \frac{v_f - v_i}{a} = \frac{0 - 25.0\ \text{m/s}}{-9.80\ \text{m/s}^2} = \boxed{2.55\ \text{s}}.$$

(c) The time required for the ball to fall 31.9 m, starting from rest, is found from

$$\Delta y = (0)t + \frac{1}{2}at^2 \text{ as } t = \sqrt{\frac{2(\Delta y)}{a}} = \sqrt{\frac{2(-39.1\ \text{m})}{-9.80\ \text{m/s}^2}} = \boxed{2.55\ \text{s}}.$$

(d) The velocity of the ball when it returns to the original level (2.55 s after it starts to fall from rest) is

$$v_f = v_i + at = 0 + (-9.80\ \text{m/s}^2)(2.55\ \text{s}) = \boxed{-25.0\ \text{m/s}}.$$

3.26 The time of flight for Tom is found from $\Delta y = v_{iy}t + \frac{1}{2}a_y t^2$ with $v_{iy} = 0$:

$$t = \sqrt{\frac{2(\Delta y)}{a}} = \sqrt{\frac{2(-1.5\ \text{m})}{-9.80\ \text{m/s}^2}} = 0.55\ \text{s}.$$

The horizontal displacement during this time is

$$\Delta x = v_{ix} t = (5.0\ \text{m/s})(0.55\ \text{s}) = 2.8\ \text{m}.$$

Thus, he lands $\boxed{2.8\ \text{m from the base of the table}}$.

The horizontal component of velocity does not change during the flight, so $v_x = v_{ix} = \boxed{5.0\ \text{m/s}}$.
The vertical component of velocity is found as

$$v_y = v_{iy} + a_y t = 0 - (-9.80\ \text{m/s}^2)(0.55\ \text{s}) = \boxed{-5.4\ \text{m/s}}.$$

3.29 We choose our origin at the initial position of the projectile. After 3.00 s, it is at ground level, so the vertical displacement is $\Delta y = -H$.

To find H, we use $\Delta y = v_{iy} t + \frac{1}{2} a_y t^2$, which becomes

$$-H = (15\ \text{m/s})(\sin 25°)(3.0\ \text{s}) + \frac{1}{2}(-9.80\ \text{m/s}^2)(3.0\ \text{s})^2, \text{ or } H = \boxed{25\ \text{m}}.$$

3.30 The components of the initial velocity are:

$$v_{ix} = v_i \cos 53.0° = 12.0\ \text{m/s}, \text{ and } v_{iy} = v_i \sin 53.0° = 16.0\ \text{m/s}.$$

(a) The time required for the ball to reach the position of the crossbar is

$$t = \frac{\Delta x}{v_{ix}} = \frac{36.0\ \text{m}}{12.0\ \text{m/s}} = 3.00\ \text{s}.$$

At this time, the height of the football above the ground is

$$\Delta y = v_{iy} t + \frac{1}{2} a_y t^2 = \left(16.0\ \frac{\text{m}}{\text{s}}\right)(3.00\ \text{s}) + \frac{1}{2}\left(-9.80\ \frac{\text{m}}{\text{s}^2}\right)(3.00\ \text{s})^2 = 3.90\ \text{m}$$

Thus, the ball $\boxed{\text{clears the crossbar by } 3.90\ \text{m} - 3.05\ \text{m} = 0.85\text{m}}$.

(b) The vertical component of the velocity of the ball as it moves over the crossbar is $v_y = v_{iy} + a_y t = (16.0\ \text{m/s}) + (-9.80\ \text{m/s}^2)(3.00\ \text{s}) = -13.4\ \text{m/s}$. The negative sign indicates the ball is moving downward or $\boxed{\text{falling}}$.