HW2

2. ***REASONING AND SOLUTION*** The buses *do not* have equal velocities. Velocity is a vector, with both magnitude and direction. In order for two vectors to be equal, they must have the same magnitude and the same direction. The direction of the velocity of each bus points in the direction of motion of the bus. Thus, the directions of the velocities of the buses are different. Therefore, the velocities are not equal, even though the speeds are the same.

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3. **SSM** ***REASONING AND SOLUTION*** The moving plane can be seen through the window of the stationary plane for the time that it takes the moving plane to travel its own length. To find the time, we write Equation 2.1 as

$$\text{Elapsed time} = \frac{\text{Distance}}{\text{Average speed}} = \frac{36\text{ m}}{45\text{ m/s}} = \boxed{0.80\text{ s}}$$

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8. ***REASONING AND SOLUTION*** Her average speed is the total distance she falls divided by the total time of the fall:

$$v = \frac{x}{t} = \frac{625\text{ m} + 356\text{ m}}{15.0\text{ s} + 142\text{ s}} = \boxed{6.25\text{ m/s}}$$

The direction of the velocity is $\boxed{\text{downward}}$.

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15. **SSM** ***REASONING AND SOLUTION*** The initial velocity of the runner can be found by solving Equation 2.4 ($v = v_0 + at$) for v_0. Taking west as the positive direction, we have

$$v_0 = v - at = (+5.36\text{ m/s}) - (+0.640\text{ m/s}^2)(3.00\text{ s}) = +3.44\text{ m/s}$$

Therefore, the initial velocity of the runner is $\boxed{3.44\text{ m/s, due west}}$.

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22. ***REASONING AND SOLUTION***

a. From Equation 2.4, the definition of average acceleration, the magnitude of the average acceleration of the skier is

$$\bar{a} = \frac{v - v_0}{t - t_0} = \frac{8.0\text{ m/s} - 0\text{ m/s}}{5.0\text{ s}} = \boxed{1.6\text{ m/s}^2}$$

b. With x representing the displacement traveled along the slope, Equation 2.7 gives:

$$x = \tfrac{1}{2}(v_0 + v)t = \tfrac{1}{2}(8.0 \text{ m/s} + 0 \text{ m/s})(5.0 \text{ s}) = \boxed{2.0 \times 10^1 \text{ m}}$$

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28. ***REASONING AND SOLUTION*** The speed of the car at the end of the first (402 m) phase can be obtained as follows:

$$v_1^2 = v_o^2 + 2a_1x_1$$

$$v_1 = \sqrt{2(17.0 \text{ m/s}^2)(402 \text{ m})}$$

The speed after the second phase (3.50×10^2 m) can be obtained in a similar fashion.

$$v_2^2 = v_{02}^2 + 2a_2x_2$$

$$v_2 = \sqrt{v_1^2 + 2(-6.10 \text{ m/s}^2)(3.50 \text{ x } 10^2 \text{ m})}$$

$$v_2 = \boxed{96.9 \text{ m/s}}$$

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35. **SSM** ***REASONING*** As the train passes through the crossing, its motion is described by Equations 2.4 ($v = v_0 + at$) and 2.7 $\left[x = \tfrac{1}{2}(v + v_0)t\right]$, which can be rearranged to give

$$v - v_0 = at \qquad \text{and} \qquad v + v_0 = \frac{2x}{t}$$

These can be solved simultaneously to obtain the speed v when the train reaches the end of the crossing. Once v is known, Equation 2.4 can be used to find the time required for the train to reach a speed of 32 m/s.

SOLUTION Adding the above equations and solving for v, we obtain

$$v = \frac{1}{2}\left(at + \frac{2x}{t}\right) = \frac{1}{2}\left[(1.6 \text{ m/s}^2)(2.4 \text{ s}) + \frac{2(20.0 \text{ m})}{2.4 \text{ s}}\right] = 1.0 \times 10^1 \text{ m/s}$$

The motion from the end of the crossing until the locomotive reaches a speed of 32 m/s requires a time

$$t = \frac{v - v_0}{a} = \frac{32 \text{ m/s} - 1.0 \times 10^1 \text{ m/s}}{1.6 \text{ m/s}^2} = \boxed{14 \text{ s}}$$

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41. SSM ***REASONING AND SOLUTION*** Since the balloon is released from rest, its initial velocity is zero. The time required to fall through a vertical displacement y can be found from Equation 2.8 $\left(y = v_0 t + \frac{1}{2} a t^2 \right)$ with $v_0 = 0$ m/s. Assuming upward to be the positive direction, we find

$$t = \sqrt{\frac{2y}{a}} = \sqrt{\frac{2(-6.0 \text{ m})}{-9.80 \text{ m/s}^2}} = \boxed{1.1 \text{ s}}$$

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53. SSM WWW ***REASONING AND SOLUTION*** The stone requires a time, t_1, to reach the bottom of the hole, a distance y below the ground. Assuming downward to be the positive direction, the variables are related by Equation 2.8 with $v_0 = 0$ m/s:

$$y = \tfrac{1}{2} a t_1^2 \qquad (1)$$

The sound travels the distance y from the bottom to the top of the hole in a time t_2. Since the sound does not experience any acceleration, the variables y and t_2 are related by Equation 2.8 with $a = 0$ m/s^2 and v_{sound} denoting the speed of sound:

$$y = v_{\text{sound}}\, t_2 \qquad (2)$$

Equating the right hand sides of Equations (1) and (2) and using the fact that the total elapsed time is $t = t_1 + t_2$, we have

$$\tfrac{1}{2} a t_1^2 = v_{\text{sound}} t_2 \qquad \text{or} \qquad \tfrac{1}{2} a t_1^2 = v_{\text{sound}} (t - t_1)$$

Rearranging gives

$$\tfrac{1}{2} a t_1^2 + v_{\text{sound}} t_1 - v_{\text{sound}} t = 0$$

Substituting values and suppressing units for brevity, we obtain the following quadratic equation for t_1:

$$4.90 t_1^2 + 343 t_1 - 514 = 0$$

From the quadratic formula, we obtain

$$t_1 = \frac{-343 \pm \sqrt{(343)^2 - 4(4.90)(-514)}}{2(4.90)} = 1.47 \text{ s} \quad \text{or} \quad -71.5 \text{ s}$$

The negative time corresponds to a nonphysical result and is rejected. The depth of the hole is then found using Equation 2.8 with the value of t_1 obtained above:

$$y = v_0 t_1 + \tfrac{1}{2} a t_1^2 = (0\ \text{m/s})(1.47\ \text{s}) + \tfrac{1}{2}(9.80\ \text{m/s}^2)(1.47\ \text{s})^2 = \boxed{10.6\ \text{m}}$$

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58. ***REASONING AND SOLUTION*** The average acceleration for each segment is the slope of that segment.

$$a_A = \frac{40\ \text{m/s} - 0\ \text{m/s}}{21\ \text{s} - 0\ \text{s}} = \boxed{1.9\ \ \text{m/s}^2}$$

$$a_B = \frac{40\ \text{m/s} - 40\ \text{m/s}}{48\ \text{s} - 21\ \text{s}} = \boxed{0\ \text{m/s}^2}$$

$$a_C = \frac{80\ \text{m/s} - 40\ \text{m/s}}{60\ \text{s} - 48\ \text{s}} = \boxed{3.3\ \text{m/s}^2}$$

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60. ***REASONING AND SOLUTION***

a. The sign of the average velocity during a segment corresponds to the sign of the *slope* of the segment. The slope, and hence the average velocity, is *positive* for segments A and D, *negative* for segment C, and ZERO for segment B.

b.

$$v_A = \frac{1.00\ \text{km} - 0\ \text{km}}{0.20\ \text{s} - 0\ \text{s}} = \boxed{5.0\ \text{km/h}}$$

$$v_B = \frac{1.00\ \text{km} - 1.00\ \text{km}}{0.40\ \text{s} - 0.20\ \text{s}} = \boxed{0.0\ \text{km/h}}$$

$$v_C = \frac{0.25\ \text{km} - 1.00\ \text{km}}{0.60\ \text{s} - 0.40\ \text{s}} = \boxed{-3.8\ \text{km/h}}$$

$$v_D = \frac{1.25\ \text{km} - 0.25\ \text{km}}{1.00\ \text{s} - 0.60\ \text{s}} = \boxed{2.5\ \text{km/h}}$$
