2.4. Model: The jogger is a particle.
Solve: The slope of the position-versus-time graph at every point gives the velocity at that point. The slope at $t = 10$ s is

$$v = \frac{\Delta s}{\Delta t} = \frac{50 \text{ m} - 25 \text{ m}}{20 \text{ s}} = 1.25 \text{ m/s}$$

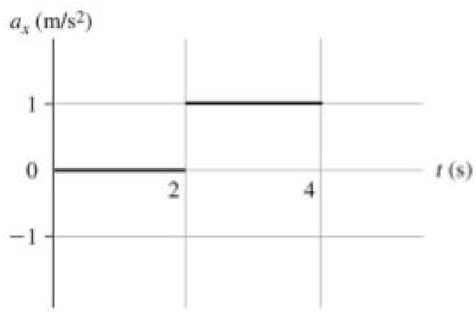
The slope at $t = 25$ s is

$$v = \frac{50 \text{ m} - 50 \text{ m}}{10 \text{ s}} = 0.0 \text{ m/s}$$

The slope at $t = 35$ s is

$$v = \frac{0 \text{ m} - 50 \text{ m}}{10 \text{ s}} = -5.0 \text{ m/s}$$

2.9. Visualize: The object has a constant velocity for 2 s and then speeds up between $t = 2$ and $t = 4$.
Solve: A constant velocity from $t = 0$ s to $t = 2$ s means zero acceleration. On the other hand, a linear increase in velocity between $t = 2$ s and $t = 4$ s implies a constant positive acceleration which is the slope of the velocity line.



2.12. Solve: (a) Using the equation

$$x_f = x_i + \text{area under the velocity-versus-time graph between } t_i \text{ and } t_f$$

we have

$$\begin{aligned} x(\text{at } t = 1 \text{ s}) &= x(\text{at } t = 0 \text{ s}) + \text{area between } t = 0 \text{ s and } t = 1 \text{ s} \\ &= 2.0 \text{ m} + (4 \text{ m/s})(1 \text{ s}) = 6 \text{ m} \end{aligned}$$

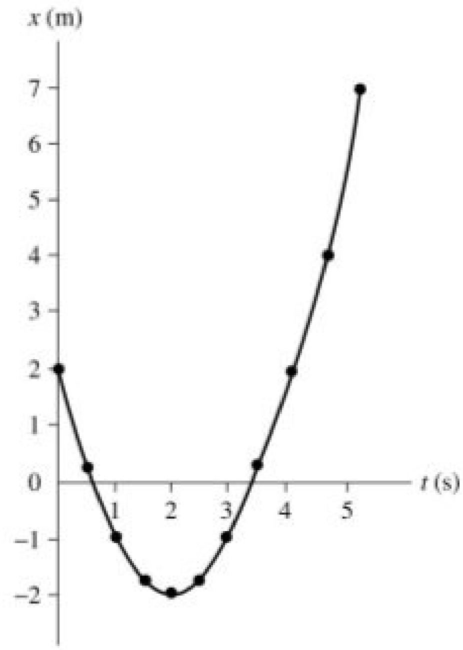
Reading from the velocity-versus-time graph, $v_x(\text{at } t = 1 \text{ s}) = 4$ m/s. Also, $a_x = \text{slope} = \Delta v / \Delta t = 0 \text{ m/s}^2$.
(b) $x(\text{at } t = 3.0 \text{ s}) = x(\text{at } t = 0 \text{ s}) +$ area between $t = 0$ s and $t = 3$ s

$$= 2.0 \text{ m} + 4 \text{ m/s} \times 2 \text{ s} + 2 \text{ m/s} \times 1 \text{ s} + (1/2) \times 2 \text{ m/s} \times 1 \text{ s} = 13.0 \text{ m}$$

Reading from the graph, $v_x(t = 3 \text{ s}) = 2$ m/s. The acceleration is

$$a_x(t = 3 \text{ s}) = \text{slope} = \frac{v_x(\text{at } t = 4 \text{ s}) - v_x(\text{at } t = 2 \text{ s})}{2 \text{ s}} = -2 \text{ m/s}^2$$

2.26. Solve: (a)



(b) To be completed by student.

(c) $\dfrac{dx}{dt} = v_x = 2t - 4 \Rightarrow v_x(\text{at } t = 1\text{ s}) = [2\text{ m/s}^2(1\text{ s}) - 4\text{ m/s}] = -2\text{ m/s}$

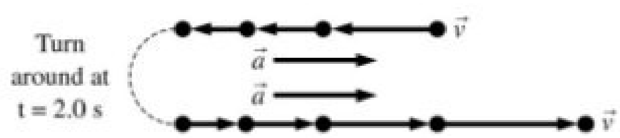
(d) There is a turning point at $t = 2$ s. At that time $x = -2$ m.

(e) Using the equation in part (c),

$$v_x = 4\text{ m/s} = (2t - 4)\text{ m/s} \Rightarrow t = 4$$

Since $x = (t^2 - 4t + 2)$ m, $x = 2$ m.

(f)



2.14. Model: Model the air as a particle.

Visualize: Use the definition of acceleration and then convert units.

Solve:

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{150\text{ km/h}}{0.50\text{ s}}\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ h}}{60\text{ min}}\right)\left(\frac{1\text{ min}}{60\text{ s}}\right) = 83\text{ m/s}^2$$

Assess: 83 m/s^2 is a remarkable acceleration.

2.15. Model: We are using the particle model for the skater and the kinematics model of motion under constant acceleration.

Solve: Since we don't know the time of acceleration we will use

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

$$\Rightarrow a = \frac{v_f^2 - v_i^2}{2(x_f - x_i)} = \frac{(6.0\text{ m/s})^2 - (8.0\text{ m/s})^2}{2(5.0\text{ m})} = -2.8\text{ m/s}^2$$

Assess: A deceleration of 2.8 m/s^2 is reasonable.

2.27. Solve: The graph for particle A is a straight line from $t = 2$ s to $t = 8$ s. The slope of this line is -10 m/s, which is the velocity at $t = 7.0$ s. The negative sign indicates motion toward lower values on the x-axis. The velocity of particle B at $t = 7.0$ s can be read directly from its graph. It is -20 m/s. The velocity of particle C can be obtained from the equation

$$v_f = v_i + \text{area under the acceleration curve between } t_i \text{ and } t_f$$

This area can be calculated by adding up three sections. The area between $t = 0$ s and $t = 2$ s is 40 m/s, the area between $t = 2$ s and $t = 5$ s is 45 m/s, and the area between $t = 5$ s and $t = 7$ s is -20 m/s. We get $(10\text{ m/s}) + (40\text{ m/s}) + (45\text{ m/s}) - (20\text{ m/s}) = 75\text{ m/s}$.

2.30. Solve: The given function for the velocity is $v_x = t^2 - 7t + 10$.

(a) The turning points are when the velocity changes sign. Set $v_x = 0$ and check that it actually changes sign at those times. The function factors into the product of two binomials:

$$v_x = (t-2)(t-5) \Rightarrow v_x = 0 \text{ when } t = 2\text{ s and } t = 5\text{ s}$$

Indeed, the function changes sign at those two times.

(b) The acceleration is given by the derivative of the velocity.

$$a_x = \frac{dv_x}{dt} = 2t - 7$$

Plug in the times from part (a): $a_x(2\text{ s}) = 2(2) - 7 = -3\text{ m/s}^2$ and $a_x(5\text{ s}) = 2(5) - 7 = 3\text{ m/s}^2$

Assess: This problem does not have constant acceleration so the kinematic equations do not apply, but $a = dv/dt$ always applies.