2

KINEMATICS IN ONE DIMENSION

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

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

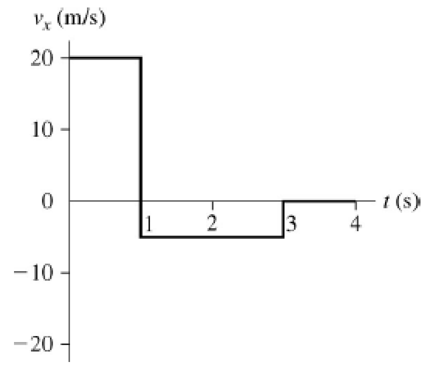
The slope at $t = 25$ s is

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

The slope at $t = 35$ s is

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

2.5. Solve: (a) We can obtain the values for the velocity-versus-time graph from the equation $v = \Delta s/\Delta t$.



(b) There is only one turning point. At $t = 1$ s the velocity changes from +20 m/s to −5 m/s, thus reversing the direction of motion. At $t = 3$ s, there is an abrupt change in motion from −5 m/s to rest, but there is no reversal in motion.

2.6. Visualize: Please refer to Figure EX2.6. The particle starts at $x_0 = 10$ m at $t_0 = 0$. Its velocity is initially in the $-x$ direction. The speed decreases as time increases during the first second, is zero at $t = 1$ s, and then increases after the particle reverses direction.

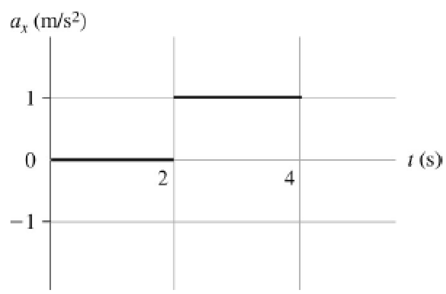
Solve: **(a)** The particle reverses direction at $t = 1$ s, when v_x changes sign.

(b) Using the equation $x_f = x_0 +$ area of the velocity graph between t_1 and t_f,

$$x_{2s} = 10\text{ m} - (\text{area of triangle between 0 s and 1 s}) + (\text{area of triangle between 1 s and 2 s})$$
$$= 10\text{ m} - \frac{1}{2}(4\text{ m/s})(1\text{ s}) + \frac{1}{2}(4\text{ m/s})(1\text{ s}) = 10\text{ m}$$
$$x_{3s} = 10\text{ m} + \text{area of trapazoid between 2 s and 3 s}$$
$$= 10\text{ m} + \frac{1}{2}(4\text{ m/s} + 8\text{ m/s})(3\text{ s} - 2\text{ s}) = 16\text{ m}$$
$$x_{4s} = x_{3s} + \text{area between 3 s and 4 s}$$
$$= 16\text{ m} + \frac{1}{2}(8\text{ m/s} + 12\text{ m/s})(1\text{ s}) = 26\text{ m}$$

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.



2.11. Solve: **(a)** At $t = 2.0$ s, the position of the particle is

$$x_{2\text{ s}} = 2.0\text{ m} + \text{area under velocity graph from } t = 0\text{ s to } t = 2.0\text{ s}$$
$$= 2.0\text{ m} + \frac{1}{2}(4.0\text{ m/s})(2.0\text{ s}) = 6.0\text{ m}$$

(b) From the graph itself at $t = 2.0$ s, $v = 4$ m/s.

(c) The acceleration is

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_{fx} - v_{ix}}{\Delta t} = \frac{6\text{ m/s} - 0\text{ m/s}}{3\text{ s}} = 2\text{ m/s}^2$$

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

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

Reading from the velocity-versus-time graph, $v_x(\text{at } t = 1\text{ s}) = 4\text{ m/s}$. 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 $t = 0\text{ s}$ and $t = 3\text{ s}$

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

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

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

2.38. Visualize: Please refer to Figure P2.38.

Solve: