2-1 Speed, Displacement, and Velocity

1. A runner runs 2 km in 5 min and then takes 10 min to walk back to the starting point. (a) What is the average velocity for the first 5 min? (b) What is the average velocity for the time spent walking? (c) What is the average velocity for the total trip? (d) What is the average speed for the total trip?

3. A particle is at \( x = +5 \) m at \( t = 0 \), \( x = -7 \) m at \( t = 6 \) s, and \( x = +2 \) m at \( t = 10 \) s. Find the average velocity of the particle during the intervals (a) \( t = 0 \) to \( t = 6 \) s, (b) \( t = 6 \) s to \( t = 10 \) s, and (c) \( t = 0 \) to \( t = 10 \) s.

5. A car travels in a straight line with an average velocity of 80 km/h for 2.5 h and then with an average velocity of 40 km/h for 1.5 h. (a) What is the total displacement for the 4-h trip? (b) What is the average velocity for the total trip?

11. A car making a 100-km journey covers the first 50 km at 40 km/h. How fast must it cover the second 50 km to average 50 km/h?

2-2 Instantaneous Velocity

12. For each of the four graphs of \( x \) versus \( t \) in Figure 2-13, indicate whether (a) the velocity at time \( t_2 \) is greater than, less than, or equal to the velocity at time \( t_1 \) and (b) the speed at time \( t_2 \) is greater than, less than, or equal to the speed at time \( t_1 \).

Figure 2-13 Graphs of \( x \) versus \( t \) for Problem 12.

\[ \text{Figure 2-17} \quad \text{Graphs of } x \text{ versus } t \text{ for Problem 18.} \]

17. At \( t = 5 \) s an object is traveling at 5 m/s. At \( t = 8 \) s its velocity is -1 m/s. Find the average acceleration for this interval.

18. State whether the acceleration is positive, negative, or zero for each of the position functions \( x(t) \) in Figure 2-17.
Solutions

1. a) First 5 min \( V_{\text{ave}} = \frac{2-0}{5-0} = \frac{2}{5} \text{ km/min} = 2.4 \text{ km/h} \)

   b) Walking \( V_{\text{ave}} = \frac{0-2}{15-5} = -\frac{3}{10} \text{ km/min} = -12 \text{ km/h} \)

   c) Total trip \( V_{\text{ave}} = \frac{0-0}{15-0} = 0 \text{ km/min} = 0 \text{ km/h} \)

   d) Total trip Speed \( V_{\text{ave}} = \frac{2 \text{ km} + 2 \text{ km}}{5 \text{ min} + 10 \text{ min}} = \frac{4 \text{ km}}{15 \text{ min}} = 16 \text{ km/h} \)

3. a) \( t: 0 \text{ to } 6 \text{ s} \) \( V_{\text{ave}} = \frac{7-5}{6-0} = \frac{2}{3} = 2 \text{ m/s} \)

   b) \( t: 6 \text{ to } 10 \text{ s} \) \( V_{\text{ave}} = \frac{2-(7)}{10-6} = \frac{9}{4} = 2.25 \text{ m/s} \)

   c) \( t: 0 \text{ to } 10 \text{ s} \) \( V_{\text{ave}} = \frac{2-5}{10-0} = \frac{-3}{10} = -0.3 \text{ m/s} \)

5. \( d_{\text{total}} = d_1 + d_2 \)
   \( d_1 = 80 \text{ km/h} \times 2.5 \text{ h} = 200 \text{ km} \)
   \( d_2 = 40 \text{ km/h} \times 1.5 \text{ h} = 60 \text{ km} \)

   Thus total displacement = \( d_{\text{total}} = d_1 + d_2 = 260 \text{ km} \)

   Total time = \( 2.5 \text{ h} + 1.5 \text{ h} = 4.0 \text{ hr} \)

   For entire scenario, \( V_{\text{ave}} = \frac{260 \text{ km}}{4.0 \text{ h}} = 65 \text{ km/h} \)

11. The first 50 km requires \( t = \frac{\text{disp.}}{V} = \frac{50 \text{ km}}{40 \text{ km/h}} = 1.25 \text{ h} \)

   But the entire trip of 100 km has an \( V_{\text{ave}} = 50 \text{ km/h} \)

   Thus time for entire trip is \( t_{\text{total}} = \frac{100 \text{ km}}{50 \text{ km/h}} = 2.0 \text{ h} \)

   Thus only 2.0 h - 1.25 hr = 0.75 h is left for the second half (50 km) of the trip.

   Thus average velocity during this second half must be \( V_{\text{ave}} = \frac{50 \text{ km}}{0.75 \text{ h}} = 66.7 \text{ km/h} \)
12. Graph a: $v_{t_2} < v_{t_1}$, Speed $t_2 < Speed t_1$

Graph b: $v_{t_2} = v_{t_1}$, Speed $t_2 = Speed t_1$

Graph c: $v_{t_2} > v_{t_1}$, Speed $t_2 > Speed t_1$

Graph d: $v_{t_2} < v_{t_1}$, Speed $t_2 > Speed t_1$

17. $\alpha_{avg} = \frac{v_{t_2} - v_{t_1}}{t_2 - t_1} = \frac{-1-5}{8-5} = \frac{-6}{3} = -2 \text{m/s}^2$

18. Graph a: $v$ is constant $\rightarrow a = 0$

Graph b: $v$ is increasing $\rightarrow a > 0$

Graph c: $v$ is decreasing $\rightarrow a < 0$

Graph d: $v$ is constant $\rightarrow a = 0$