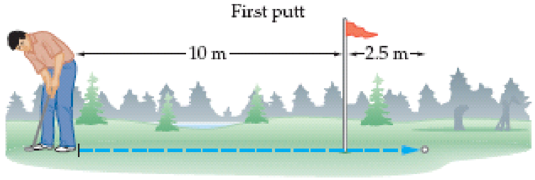
Chapter 2: Introduction to Physics

Answers to Problems & Conceptual Exercises

2. The ball is putted in the positive direction and then the negative direction.

The distance is the total length of travel, and the displacement is the net change in position.



(a)

The distance traveled is : $d = 10\ m + 2.5\ m + 2.5\ m = 15\ m$

(b) Displacement is: $\Delta x = x_f - x_i = 10 - 0 = 10\ m$

Or $\Delta x = +10\ m + 2.5\ m - 2.5\ m = 10\ m$

5. The runner moves along the oval track. The distance is the total length of travel, and the displacement is the net change in position.

1. **(a)** Add the lengths: $(15\text{ m}) + (100\text{ m}) + (15\text{ m}) = \boxed{130\text{ m}}$

2. **(a)** Subtract x_i from x_f to find the displacement. $\Delta x = x_f - x_i = 100 - 0\text{ m} = \boxed{100\text{ m}}$

3. **(a)** Add the lengths: $15 + 100 + 30 + 100 + 15\text{ m} = \boxed{260\text{ m}}$

4. **(a)** Subtract x_i from x_f to find the displacement. $\Delta x = x_f - x_i = 0 - 0\text{ m} = \boxed{0\text{ m}}$

10. The swimmer swims in the forward direction.

$$d = st = \left(65\ \frac{\text{km}}{\text{h}}\right)\left(3.2\text{ min} \times \frac{1\text{ h}}{60\text{ min}}\right) = \boxed{3.5\text{ km}}$$

$$t = \frac{d}{s} = \frac{0.25\text{ km}}{65\text{ km/h}} \times \frac{60\text{ min}}{1\text{ h}} = \boxed{14\text{ s}}$$

18.

The Problem: You travel 8.0 km on foot and then an additional 16 km by car, with both displacements along the same direction.

Strategy: First find the total time elapsed by dividing the distance traveled by the average and divide by the total time elapsed to find the average speed. Set that average speed to the given value and solve for the car's speed.

Solution: 1. Use the definition of average speed to determine the total time elapsed.

$$\Delta t = \frac{d}{s_{av}} = \frac{8.0 + 16 \text{ km}}{22 \text{ km/h}} = 1.1 \text{ h}$$

2. Find the time elapsed while in the car:

$$\Delta t_2 = \Delta t - \Delta t_1 = 1.1 \text{ h} - 0.84 \text{ h} = 0.3 \text{ h}$$

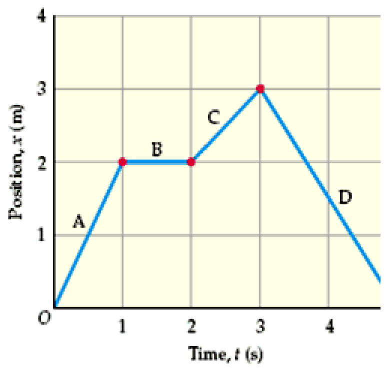
3. Find the speed of the car:

$$s_2 = \frac{d_2}{\Delta t_2} = \frac{16 \text{ km}}{0.3 \text{ h}} = \boxed{50 \text{ km/h}}$$

Check Point: This problem illustrates the limitations that significant figures occasionally impose. If you keep an extra figure in the total elapsed time (1.09 h) you'll end up with the time elapsed for the car trip as 0.25 h, not 0.3, and the speed of the car is 64 km/h. But the rules of subtraction indicate we only know the total time to within a tenth of an hour, so we can only know the time spent in the car to within a tenth of an hour, or to within one significant digit.

23.

The Problem: Following the motion specified in the position-*versus*-time graph, the father walks forward, stops, walks forward again, and then walks backward.



Strategy: Determine the direction of the velocity from the slope of the graph. Then determine the magnitude of the velocity by calculating the slope of the graph at each specified point.

Solution: 1. (a) The slope at A is positive so the velocity is $\boxed{\text{positive}}$.

(b) The velocity at B is $\boxed{\text{zero}}$. **(c)** The velocity at C is $\boxed{\text{positive}}$. **(d)** The velocity at D is $\boxed{\text{negative}}$.

2. (e) Find the slope of the graph at A: $v_{av} = \frac{\Delta x}{\Delta t} = \frac{2.0 \text{ m}}{1.0 \text{ s}}$

3. (f) Find the slope of the graph at B: $v_{av} = \frac{\Delta x}{\Delta t} = \frac{0.0 \text{ m}}{1.0 \text{ s}} = \boxed{0.0 \text{ m/s}}$

4. (g) Find the slope of the graph at C: $v_{av} = \frac{\Delta x}{\Delta t} = \frac{1.0 \text{ m}}{1.0 \text{ s}} = \boxed{1.0 \text{ m/s}}$

5. (h) Find the slope of the graph at D: $v_{av} = \frac{\Delta x}{\Delta t} = \frac{-3.0 \text{ m}}{2.0 \text{ s}} = \boxed{-1.5 \text{ m/s}}$

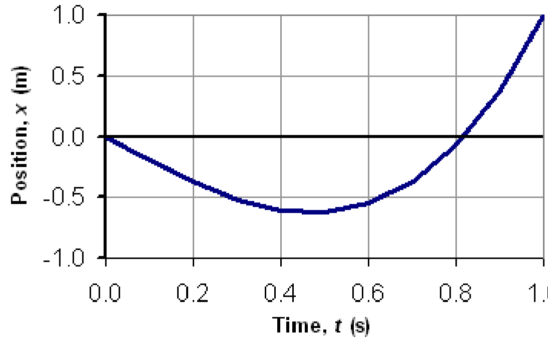
Check Point: The signs of each answer in (e) through (h) match those predicted in parts (a) through (d). With practice you can form both a qualitative and quantitative "movie" of the motion in your head simply by examining the position-*versus*-time graph.

30.

The Problem: The given position function indicates the particle begins traveling in the negative direction but is accelerating in the positive direction.

Strategy: Create the *x-versus-t* plot using a spreadsheet, or calculate individual values by hand and sketch the curve using graph paper. Use the known *x* and *t* information to determine the average speed and velocity.

Solution: 1. (a) Use a spreadsheet to create the plot:



2. (b) Find the average velocity from $t = 0.150$ to $t = 0.250$ s:

$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{\left(\left[(-2\text{ m/s})(0.250\text{ s})+(3\text{ m/s}^3)(0.250\text{ s})^3\right]-\left[(-2\text{ m/s})(0.150\text{ s})+(3\text{ m/s}^3)(0.150\text{ s})^3\right]\right)}{0.250-0.150\text{ s}} = \boxed{-1.6}$$

3. (c) Find the average velocity from $t = 0.190$ to $t = 0.210$ s:

$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{\left(\left[(-2\text{ m/s})(0.210\text{ s})+(3\text{ m/s}^3)(0.210\text{ s})^3\right]-\left[(-2\text{ m/s})(0.190\text{ s})+(3\text{ m/s}^3)(0.190\text{ s})^3\right]\right)}{0.210-0.190\text{ s}} = \boxed{-1.6}$$

4. (d) The instantaneous speed at $t = 0.200$ s will be $\boxed{\text{closer to } -1.64\text{ m/s}}$. As the time interval becomes smaller the average velocity is approaching −1.64 m/s, so we conclude the average speed over an infinitesimally small time interval will be very close to that value.

Check Point: Note that the instantaneous velocity at 0.200 s is equal to the slope of a straight line drawn tangent to the curve at that point. Because it is difficult to accurately draw a tangent line, we usually resort to mathematical methods like those illustrated above to determine the instantaneous velocity.

. **38.**

The Problem: The horse travels in a straight line in the positive direction while accelerating in the negative direction (slowing down).

Strategy: Use the definition of acceleration to determine the time elapsed for the specified change in velocity.

Solution: Solve equation 2-7 for time:

$$t = \frac{v - v_0}{a} = \frac{6.5 - 11\text{ m/s}}{-1.81\text{ m/s}^2} = \boxed{2.5\text{ s}}$$

Check Point: We bent the rules a little bit on significant figures. Because the +11 m/s is only known to the ones column, the difference between 6.5 and 11 is 4 m/s, only one significant digit. The answer is then properly 2 s. The answer is probably closer to 2.5 s, so that's why we kept the extra digit.

42.

The Problem: The particle travels in a straight line in the positive direction while accelerating in the positive direction (speeding up).

Strategy: Use the constant acceleration equation of motion to find the initial velocity.

Solution: Solve equation 2-7 for v_0: $v_0 = v - at = 9.31\text{ m/s} - (6.24\text{ m/s}^2)(0.300\text{ s}) = \boxed{7.44\text{ m/s}}$

Check Point: As expected the initial velocity is less than the final velocity because the particle is speeding up.

46. Multiply the known quantity by appropriate conversion factors to change the units.

(a) The acceleration must be **greater than** **14 ft/s²** because there are about 3 ft per meter.

Convert m/s² to ft/s²:

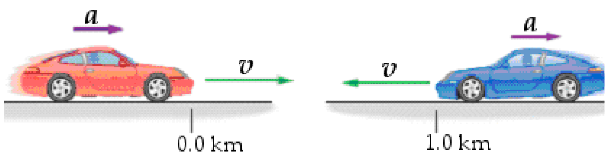
$$\left(14\ \frac{\text{m}}{\text{s}^2}\right)\left(\frac{3.28\text{ ft}}{\text{m}}\right) = \boxed{46\ \frac{\text{ft}}{\text{s}^2}}$$

Convert m/s² to km/h²:

$$\left(14\ \frac{\text{m}}{\text{s}^2}\right)\left(\frac{1\text{ km}}{1000\text{ m}}\right)\left(\frac{3600\text{ s}}{\text{h}}\right)^2 = \boxed{1.8\times10^5\ \frac{\text{km}}{\text{h}^2}}$$

54.

The Problem: The two cars are traveling in opposite directions.



Strategy: Write the equations of motion based upon equation 2-11, and set them equal to each other to find the time at which the two cars pass each other.

Solution: 1. (a) Write equation 2-11 for car 1: $x_1 = x_{0,1} + v_{0,1}t + \frac{1}{2}a_1t^2 = 0 + (20.0\text{ m/s})t + (1.25\text{ m/s}^2)t^2$

2. Write equation 2-11 for car 2: $x_2 = x_{0,2} + v_{0,2}t + \frac{1}{2}a_2t^2 = 1000\text{ m} - (30.0\text{ m/s})t + (1.6\text{ m/s}^2)t$

3. (b) Set $x_1 = x_2$ and solve for t:

$$\left(20.0\ \text{m/s}\right)t + \left(1.25\ \text{m/s}^2\right)t^2 = 1000\ \text{m} - \left(30.0\ \text{m/s}\right)t + \left(1.6\ \text{n}\right.$$

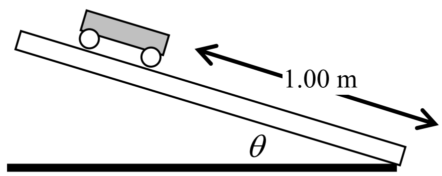
$$0 = 1000 - 50t + 0.35t^2$$

$$t = \frac{50 \pm \sqrt{50^2 - 4(0.35)(1000)}}{0.70} = 24,\ 119\ \text{s} \Rightarrow \boxed{24\ \text{s}}$$

Check Point: We take the smaller of the two roots, which corresponds to the first time the cars pass each other. Later on the larger acceleration of car 2 means that it'll come to rest, speed up in the positive direction, and overtake car 1 at 119 s.

68.

The Problem: The cart slides down the inclined track, each time traveling a distance of 1.00 m along the track.



Strategy: The distance traveled by the cart is given by the constant-acceleration equation of motion for position as a function of time (equation 2-11), where $x_0 = v_0 = 0$. The magnitude of the acceleration can thus be determined from the given distance traveled and the time elapsed in each case. We can then make the comparison with $a = g\sin\theta$.

Solution: 1. Find the acceleration from equation 2-11:

$$x = 0 + 0 + \tfrac{1}{2}at^2 \quad \Rightarrow \quad a = \frac{2x}{t^2} \qquad a = g\sin\theta$$

2. Now find the values for $\theta = 10.0°$:

$$a = \frac{2.00\ \text{m}}{(1.08\ \text{s})^2} = \boxed{1.71\ \text{m/s}^2} \qquad a = \left(9.81\ \text{m/s}^2\right)\sin 10.0^\circ = \boxed{1.70\ \text{m/s}^2}$$

3. Now find the values for $\theta = 20.0°$:

$$a = \frac{2.00\ \text{m}}{(0.770\ \text{s})^2} = \boxed{3.37\ \text{m/s}^2} \qquad a = \left(9.81\ \text{m/s}^2\right)\sin 20.0^\circ = \boxed{3.35\ \text{m/s}^2}$$

4. Now find the values for $\theta = 30.0°$:

$$a = \frac{2.00\ \text{m}}{(0.640\ \text{s})^2} = \boxed{4.88\ \text{m/s}^2} \qquad a = \left(9.81\ \text{m/s}^2\right)\sin 10.0^\circ = \boxed{4.91\ \text{m/s}^2}$$

Check Point: We see very good agreement between the formula $a = g\sin\theta$ and the measured acceleration. The experimental accuracy gets more and more difficult to control as the angle gets bigger because the elapsed times become very small and more difficult to measure accurately. For this reason Galileo's experimental approach (rolling balls down an incline with a small angle) gave him an opportunity to make accurate observations about free fall without fancy electronic equipment.