Chapter 2 Group Problems

3. A cheetah is known to be the fastest mammal on Earth, at least for short runs. Cheetahs have been observed running a distance of 5.50×10^2 m with an average speed of 1.00×10^2 km/h.

a. How long would it take a cheetah to cover this distance at this speed?

b. Suppose the average speed of the cheetah were just 85.0 km/h. What distance would the cheetah cover during the same time interval calculated in (a)?

3. $\Delta x = 5.50 \times 10^2$ m

$v_{avg} = 1.00 \times 10^2$ km/h

$v_{avg} = 85.0$ km/h

a. $$\Delta t = \frac{\Delta x}{v_{avg}} = \frac{5.50 \times 10^2 \text{ m}}{\left(1.00 \times 10^2 \frac{\text{km}}{\text{h}}\right)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{1000 \text{ m}}{1 \text{ km}}\right)} = \boxed{19.8 \text{ s}}$$

b. $\Delta x = \Delta v_{avg} \Delta t$

$$\Delta x = (85.0 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)(19.8 \text{ s}) = \boxed{468 \text{ m}}$$

2. In 1935, a French destroyer, *La Terrible,* attained one of the fastest speeds for any standard warship. Suppose it took 2.0 min at a constant acceleration of 0.19 m/s^2 for the ship to reach its top speed after starting from rest. Calculate the ship's final speed.

2. $\Delta t = 2.0$ min

$a_{avg} = 0.19 \text{ m/s}^2$

$v_i = 0$ m/s

$$v_f = a_{avg} \Delta t + v_i = (0.19 \text{ m/s}^2)(2.0 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right) + 0 \text{ m/s} = \boxed{23 \text{ m/s}}$$

1. In 1993, Ileana Salvador of Italy walked 3.0 km in under 12.0 min. Suppose that during 115 m of her walk Salvador is observed to steadily increase her speed from 4.20 m/s to 5.00 m/s. How long does this increase in speed take?

1. $\Delta x = 115$ m

$v_i = 4.20$ m/s

$v_f = 5.00$ m/s

$$\Delta t = \frac{2\Delta x}{v_i + v_f} = \frac{(2)(115 \text{ m})}{4.20 \text{ m/s} + 5.00 \text{ m/s}} = \frac{(2)(115 \text{ m})}{9.20 \text{ m/s}} = \boxed{25.0 \text{ s}}$$

2. In 1976, Gerald Hoagland drove a car over 8.0×10^2 km in reverse. Fortunately for Hoagland and motorists in general, the event took place on a special track. During this drive, Hoagland's average velocity was about –15.0 m/s. Suppose Hoagland decides during his drive to go forward. He applies the brakes, stops, and then accelerates until he moves forward at same speed he had when he was moving backward. How long would the entire reversal process take if the average acceleration during this process is +2.5 m/s^2?

2. $v_i = -15.0$ m/s

$v_f = 0$ m/s

$a = +2.5$ m/s^2

$v_i = 0$ m/s

$v_f = +15.0$ m/s

$a = +2.5$ m/s

For stopping:

$$\Delta t_1 = \frac{v_f - v_i}{a} = \frac{0 \text{ m/s} - (-15.0 \text{ m/s})}{2.5 \text{ m/s}^2} = \frac{15.0 \text{ m/s}}{2.5 \text{ m/s}^2} = 6.0 \text{ s}$$

For moving forward:

$$\Delta t_2 = \frac{v_f - v_i}{a} = \frac{15.0 \text{ m/s} - 0.0 \text{ m/s}}{2.5 \text{ m/s}^2} = \frac{15.0 \text{ m/s}}{2.5 \text{ m/s}^2} = 6.0 \text{ s}$$

$$\Delta t_{tot} = \Delta t_1 + \Delta t_2 = 6.0 \text{ s} + 6.0 \text{ s} = \boxed{12.0 \text{ s}}$$

3. The Boeing 747 can carry more than 560 passengers and has a maximum speed of about 9.70×10^2 km/h. After takeoff, the plane takes a certain time to reach its maximum speed. Suppose the plane has a constant acceleration with a magnitude of 4.8 m/s^2. What distance does the plane travel between the moment its speed is 50.0 percent of maximum and the moment its maximum speed is attained?

3. $v_f = 9.70 \times 10^2$ km/h

$v_i = (0.500)v_f$

$a = 4.8$ m/s^2

$$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{\left[(9.70 \times 10^2 \text{ km/h})^2 - (0.50)^2 (9.70 \times 10^2 \text{ km/h})^2\right]\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(4.8 \text{ m/s}^2)}$$

$$\Delta x = \frac{(9.41 \times 10^5 \text{ km}^2/\text{h})^2 - 2.35 \times 10^5 \text{ km}^2/\text{h}^2)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(4.8 \text{ m/s}^2)}$$

$$\Delta x = \frac{(7.06 \times 10^5 \text{ km}^2/\text{h}^2)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(4.8 \text{ m/s}^2)}$$

$$\Delta x = \frac{5.45 \times 10^4 \text{m}^2/\text{s}^2}{9.6 \text{ m/s}^2} = 5.7 \times 10^3 \text{ m} = \boxed{5.7 \text{ km}}$$

2. Brian Berg of Iowa built a house of cards 4.88 m tall. Suppose Berg throws a ball from ground level with a velocity of 9.98 m/s straight up. What is the velocity of the ball as it first passes the top of the card house?

2. $\Delta y = +4.88\ \text{m}$

$v_i = +9.98\ \text{m/s}$

$a = -9.81\ \text{m/s}^2$

$$v_f = \sqrt{2a\Delta y + v_i^2} = \sqrt{(2)(-9.81\ \text{m/s}^2)(4.88\ \text{m}) + (9.98\ \text{m/s})^2} = \sqrt{-95.7\ \text{m}^2/\text{s}^2 + 99.6\ \text{m}^2/\text{s}^2}$$

$$v_f = \sqrt{3.90\ \text{m}^2/\text{s}^2} = \pm 1.97\ \text{m/s} = \boxed{\pm 1.97\ \text{m/s}}$$

3. The Sears Tower in Chicago is 443 m tall. Suppose a book is dropped from the top of the building. What would be the book's velocity at a point 221 m above the ground? Neglect air resistance.

3. $\Delta y = -443\ \text{m} + 221\ \text{m}$
$= -222\ \text{m}$

$a = -9.81\ \text{m/s}^2$

$v_i = 0\ \text{m/s}$

$$v_f = \sqrt{2a\Delta y - v_i^2} = \sqrt{(2)(-9.81\ \text{m/s}^2)(-222\ \text{m}) - (0\ \text{m/s})^2} = \sqrt{4360\ \text{m}^2/\text{s}^2}$$

$$v_f = \pm 66.0\ \text{m/s} = \boxed{-66.0\ \text{m/s}}$$

4. The tallest roller coaster in the world is the Desperado in Nevada. It has a lift height of 64 m. If an archer shoots an arrow straight up in the air and the arrow passes the top of the roller coaster 3.0 s after the arrow is shot, what is the initial speed of the arrow?

4. $\Delta y = +64\ \text{m}$

$a = -9.81\ \text{m/s}^2$

$\Delta t = 3.0\ \text{s}$

$$\Delta y = v_i\Delta t + \tfrac{1}{2}a\Delta t^2$$

$$v_i = \frac{\Delta y - \frac{1}{2}a\Delta t^2}{\Delta t} = \frac{64\ \text{m} - \frac{1}{2}(-9.81\ \text{m/s}^2)(3.0\ \text{s})^2}{3.0\ \text{s}} = \frac{64\ \text{m} + 44\ \text{m}}{3.0\ \text{s}}$$

$$v_i = \frac{108\ \text{m}}{3.0\ \text{s}} = 36\ \text{m/s}$$

initial speed of arrow = $\boxed{36\ \text{m/s}}$

6. The Westin Stamford Hotel in Detroit is 228 m tall. If a worker on the roof drops a sandwich, how long does it take the sandwich to hit the ground, assuming there is no air resistance? How would air resistance affect the answer?

6. $\Delta y = -228\ \text{m}$

$a = -9.81\ \text{m/s}^2$

$v_i = 0\ \text{m/s}$

When $v_i = 0\ \text{m/s}$,

$$\Delta t = \sqrt{\frac{2\Delta y}{a}} = \sqrt{\frac{(2)(-228\ \text{m})}{-9.81\ \text{m/s}^2}} = \boxed{6.82\ \text{s}}$$

In the presence of air resistance, the sandwich would require more time to fall because the downward acceleration would be reduced.