Solutions to Assignment 1

Due: 11:59pm on Thursday, September 8, 2011

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1.2. **IDENTIFY:** Convert volume units from L to in.^3.

SET UP: $1\ \text{L} = 1000\ \text{cm}^3$. $1\ \text{in.} = 2.54\ \text{cm}$

EXECUTE: $0.473\ \text{L} \times \left(\dfrac{1000\ \text{cm}^3}{1\ \text{L}}\right) \times \left(\dfrac{1\ \text{in.}}{2.54\ \text{cm}}\right)^3 = 28.9\ \text{in.}^3$.

EVALUATE: $1\ \text{in.}^3$ is greater than $1\ \text{cm}^3$, so the volume in in.^3 is a smaller number than the volume in cm^3, which is $473\ \text{cm}^3$.

1.11. **IDENTIFY:** We know the density and mass; thus we can find the volume using the relation density = mass/volume = m/V. The radius is then found from the volume equation for a sphere and the result for the volume.

SET UP: Density $= 19.5\ \text{g/cm}^3$ and $m_{\text{critical}} = 60.0\ \text{kg}$. For a sphere $V = \frac{4}{3}\pi r^3$.

EXECUTE: $V = m_{\text{critical}}/\text{density} = \left(\dfrac{60.0\ \text{kg}}{19.5\ \text{g/cm}^3}\right)\left(\dfrac{1000\ \text{g}}{1.0\ \text{kg}}\right) = 3080\ \text{cm}^3$.

$$r = \sqrt[3]{\frac{3V}{4\pi}} = \sqrt[3]{\frac{3}{4\pi}(3080\ \text{cm}^3)} = 9.0\ \text{cm}.$$

EVALUATE: The density is very large, so the 130-pound sphere is small in size.

1.15. **IDENTIFY:** Use your calculator to display $\pi \times 10^7$. Compare that number to the number of seconds in a year.

SET UP: 1 yr = 365.24 days, 1 day = 24 h, and 1 h = 3600 s.

EXECUTE: $(365.24\ \text{days/1 yr})\left(\dfrac{24\ \text{h}}{1\ \text{day}}\right)\left(\dfrac{3600\ \text{s}}{1\ \text{h}}\right) = 3.15567\ldots \times 10^7\ \text{s}$; $\pi \times 10^7\ \text{s} = 3.14159\ldots \times 10^7\ \text{s}$

The approximate expression is accurate to two significant figures. The percent error is 0.45%.

EVALUATE: The close agreement is a numerical accident.

1.17. **IDENTIFY:** Express 200 kg in pounds. Express each of 200 m, 200 cm and 200 mm in inches. Express 200 months in years.

SET UP: A mass of 1 kg is equivalent to a weight of about 2.2 lbs. $1\text{ in.} = 2.54\text{ cm}$. $1\text{ y} = 12\text{ months}$.

EXECUTE: **(a)** 200 kg is a weight of 440 lb. This is much larger than the typical weight of a man.

(b) $200\text{ m} = (2.00\times10^4\text{ cm})\left(\dfrac{1\text{ in.}}{2.54\text{ cm}}\right) = 7.9\times10^3$ inches. This is much greater than the height of a person.

(c) $200\text{ cm} = 2.00\text{ m} = 79\text{ inches} = 6.6\text{ ft}$. Some people are this tall, but not an ordinary man.

(d) $200\text{ mm} = 0.200\text{ m} = 7.9\text{ inches}$. This is much too short.

(e) $200\text{ months} = (200\text{ mon})\left(\dfrac{1\text{ y}}{12\text{ mon}}\right) = 17\text{ y}$. This is the age of a teenager; a middle-aged man is much older than this.

EVALUATE: None are plausible. When specifying the value of a measured quantity it is essential to give the units in which it is being expressed.

1.21. **IDENTIFY:** Estimate the number of blinks per minute. Convert minutes to years. Estimate the typical lifetime in years.

SET UP: Estimate that we blink 10 times per minute. $1\text{ y} = 365\text{ days}$. $1\text{ day} = 24\text{ h}$, $1\text{ h} = 60\text{ min}$. Use 80 years for the lifetime.

EXECUTE: The number of blinks is $(10\text{ per min})\left(\dfrac{60\text{ min}}{1\text{ h}}\right)\left(\dfrac{24\text{ h}}{1\text{ day}}\right)\left(\dfrac{365\text{ days}}{1\text{ y}}\right)(80\text{ y/lifetime}) = 4\times10^8$

EVALUATE: Our estimate of the number of blinks per minute can be off by a factor of two but our calculation is surely accurate to a power of 10.

1.23. **IDENTIFY:** Estimation problem

SET UP: Estimate that the pile is $18\text{ in.}\times18\text{ in.}\times5\text{ ft }8\text{ in.}$. Use the density of gold to calculate the mass of gold in the pile and from this calculate the dollar value.

EXECUTE: The volume of gold in the pile is $V = 18\text{ in.}\times18\text{ in.}\times68\text{ in.} = 22{,}000\text{ in.}^3$. Convert to cm^3:

$$V = 22{,}000\text{ in.}^3(1000\text{ cm}^3/61.02\text{ in.}^3) = 3.6\times10^5\text{ cm}^3.$$

The density of gold is 19.3 g/cm^3, so the mass of this volume of gold is

$$m = (19.3\text{ g/cm}^3)(3.6\times10^5\text{ cm}^3) = 7\times10^6\text{ g}.$$

The monetary value of one gram is \$10, so the gold has a value of $(\$10/\text{gram})(7\times10^6\text{ grams}) = \$7\times10^7$, or about $\$100\times10^6$ (one hundred million dollars).

EVALUATE: This is quite a large pile of gold, so such a large monetary value is reasonable.

2.2. **IDENTIFY:** $v_{\text{av-}x} = \dfrac{\Delta x}{\Delta t}$

SET UP: $13.5\text{ days} = 1.166\times10^6\text{ s}$. At the release point, $x = +5.150\times10^6\text{ m}$.

EXECUTE: **(a)** $v_{\text{av-}x} = \dfrac{x_2 - x_1}{\Delta t} = \dfrac{5.150\times10^6\text{ m}}{1.166\times10^6\text{ s}} = -4.42\text{ m/s}$

(b) For the round trip, $x_2 = x_1$ and $\Delta x = 0$. The average velocity is zero.

EVALUATE: The average velocity for the trip from the nest to the release point is positive.

2.3. **IDENTIFY:** Target variable is the time Δt it takes to make the trip in heavy traffic. Use Eq. (2.2) that relates the average velocity to the displacement and average time.

SET UP: $v_{\text{av-}x} = \dfrac{\Delta x}{\Delta t}$ so $\Delta x = v_{\text{av-}x}\Delta t$ and $\Delta t = \dfrac{\Delta x}{v_{\text{av-}x}}$.

EXECUTE: Use the information given for normal driving conditions to calculate the distance between the two cities:

$$\Delta x = v_{\text{av-}x}\Delta t = (105 \text{ km/h})(1 \text{ h}/60 \text{ min})(140 \text{ min}) = 245 \text{ km}.$$

Now use $v_{\text{av-}x}$ for heavy traffic to calculate Δt; Δx is the same as before:

$$\Delta t = \frac{\Delta x}{v_{\text{av-}x}} = \frac{245 \text{ km}}{70 \text{ km/h}} = 3.50 \text{ h} = 3 \text{ h and } 30 \text{ min}.$$

The trip takes an additional 1 hour and 10 minutes.

EVALUATE: The time is inversely proportional to the average speed, so the time in traffic is $(105/70)(140 \text{ min}) = 210 \text{ min}$.

2.6. **IDENTIFY:** The average velocity is $v_{\text{av-}x} = \dfrac{\Delta x}{\Delta t}$. Use $x(t)$ to find x for each t.

SET UP: $x(0) = 0$, $x(2.00 \text{ s}) = 5.60 \text{ m}$, and $x(4.00 \text{ s}) = 20.8 \text{ m}$

EXECUTE: **(a)** $v_{\text{av-}x} = \dfrac{5.60 \text{ m} - 0}{2.00 \text{ s}} = +2.80 \text{ m/s}$

(b) $v_{\text{av-}x} = \dfrac{20.8 \text{ m} - 0}{4.00 \text{ s}} = +5.20 \text{ m/s}$

(c) $v_{\text{av-}x} = \dfrac{20.8 \text{ m} - 5.60 \text{ m}}{2.00 \text{ s}} = +7.60 \text{ m/s}$

EVALUATE: The average velocity depends on the time interval being considered.

2.11. **IDENTIFY:** Find the instantaneous velocity of a car using a graph of its position as a function of time.

SET UP: The instantaneous velocity at any point is the slope of the x versus t graph at that point. Estimate the slope from the graph.

EXECUTE: A: $v_x = 6.7$ m/s; B: $v_x = 6.7$ m/s; C: $v_x = 0$; D: $v_x = -40.0$ m/s; E: $v_x = -40.0$ m/s; F: $v_x = -40.0$ m/s; G: $v_x = 0$.

EVALUATE: The sign of v_x shows the direction the car is moving. v_x is constant when x versus t is a straight line.