1.4 A computer can do \( 136.8 \text{ teracalculations} \) per second. How many calculations can it do in a microsecond?

Prefixes: \( \text{tera} = 10^{12} \) \( \text{micro} = 10^{-6} \) \( \Rightarrow \) there are \( 10^6 \text{ microseconds} (\mu \text{s}) \) in 1 second.

\[
\frac{136.8 \times 10^{12} \text{ calculations}}{\text{Second}} = 136.8 \times 10^{12} \text{ calculations} = 136.8 \times 10^6 \text{ calculations} \frac{\text{Second}}{10^6 \mu \text{s}}
\]

\Rightarrow \text{ it can do } 136.8 \times 10^6 \text{ calculations in a microsecond}

or

\[
136.8 \text{ megacalculations in a microsecond}
\]

1.6 Which of the following quantities have dimensions of distance?

a) \( Vt \). \( V = \frac{[L]}{[T]} \) \( t = [T] \) \( \Rightarrow \) \( Vt = \frac{[L]}{[T]} [T] = [L] \) = distance

b) \( \frac{1}{2} at^2 \). \( a = \frac{[L]}{[T^2]} \) \( t^2 = [T^2] \) \( \Rightarrow \frac{1}{2} at^2 = \frac{[L]}{[T^2]} [T^2] = [L] \) = distance

c) \( at \). \( at = \frac{[L]}{[T]} [T] = \frac{[L]}{[T]} = \) velocity \# distance

d) \( \frac{V^2}{a} \). \( V^2 = \frac{[L]^2}{[T]^2} \) \( \Rightarrow \frac{V^2}{a} = \frac{[L]^2}{[T]^2} \frac{[T]^2}{[L]} = [L] \) = distance

\Rightarrow a), b), and c) have units of distance
### 1.12

\[ T = 2\pi \sqrt{\frac{m}{k}} \]

Find the dimensions of \( k \) for this equation to be dimensionally correct.

\[ \Rightarrow \frac{m}{k} \text{ must have units of time} \Rightarrow \frac{m}{k} = [T^2] \Rightarrow k = \frac{[M]}{[T^2]} \]

### 1.14

The speed of light to five significant figures is \( 2.9978 \times 10^8 \text{ m/s} \).

What is the speed of light to three significant figures?

We don't just keep the first two decimal places; we must round them.

\[ 2.9978 \times 10^8 \text{ m/s} \rightarrow 3.00 \times 10^8 \text{ m/s} \]

### 1.20

A building measures approx. \( 631 \text{ m} \times 707 \text{ yd} \times 110 \text{ ft} \).

**a)** What is the volume in cubic feet?

First, convert each measurement into ft.

\[ 1 \text{ m} = 3.281 \text{ ft} \Rightarrow 631 \text{ m} = (631 \text{ m})(3.281 \text{ ft}) = 2.07 \times 10^3 \text{ ft} \]

\[ 1 \text{ yd} = 3 \text{ ft} \Rightarrow 707 \text{ yd} = (707 \text{ yd})(3 \text{ ft}) = 2.12 \times 10^3 \text{ ft} \]

\[ \Rightarrow \text{Volume} = (2.07 \times 10^3 \text{ ft})(2.12 \times 10^3 \text{ ft})(110 \text{ ft}) = 4.83 \times 10^8 \text{ ft}^3 \]

**b)** Convert the result from part a) to cubic meters.

\[ 1 \text{ m} = 3.281 \text{ ft} \Rightarrow 1 \text{ ft} = 0.305 \text{ m} \Rightarrow 1 \text{ ft}^3 = (0.305)^3 \text{ m}^3 = 2.84 \times 10^{-2} \text{ m}^3 \]

\[ \Rightarrow 4.83 \times 10^8 \text{ ft}^3 = (4.83 \times 10^8)(2.84 \times 10^{-2}) \text{ m}^3 \]

\[ = 1.37 \times 10^7 \text{ m}^3 \]
1.30 1 jiffy = the time it takes light to travel one centimeter.

   a) 1 jiffy = how many seconds?

   \[
   1 \text{jiffy} = \frac{1 \text{ cm}}{\text{speed of light}} = \frac{1 \times 10^{-2} \text{ m}}{2.9979 \times 10^8 \text{ m/s}} = \frac{1}{2.9979 \times 10^8} \text{s}
   \]

   \[
   \Rightarrow 1 \text{jiffy} = 3.3357 \times 10^{-11} \text{s}
   \]

   b) How many jiffies are in one minute?

   \[
   1 \text{jiffy} = 3.3357 \times 10^{-11} \text{s} \Rightarrow 1 \text{s} = \frac{1}{3.3357 \times 10^{-11}} \text{jiffy}
   \]

   There are 60 seconds in one minute

   \[
   \Rightarrow 1 \text{ minute} = (60)(2.9979 \times 10^{10} \text{jiffy}) = 1.7987 \times 10^{12} \text{jiffies in 1 minute}
   \]

1.38 New York is roughly 3000 miles from Seattle. When it is 10:00 AM in Seattle, it is 1:00 PM in New York. Using this information, estimate:

   a) the rotational speed of the surface of the Earth.

   The information given means that it takes 3 hours for a point on Earth's surface to travel 3000 miles.

   \[
   \Rightarrow \text{Rotational speed of surface} = \frac{3000 \text{ miles}}{3 \text{ hours}} = \frac{1000 \text{ miles}}{1 \text{ hour}}
   \]

   b) the circumference of the Earth.

   We are given that it takes 3 hours for a point on Earth's surface to travel 3000 miles and we know that it takes 24 hours for a complete rotation. We can then estimate the circumference as follows:

   \[
   3000 \text{ miles in 3 hours} \Rightarrow 24,000 \text{ miles in 24 hours}
   \]

   \[
   \Rightarrow \text{Circumference of Earth} = 24,000 \text{ miles}
   \]
c) the radius of the Earth.

We can take our estimation of the circumference and divide by 2π to obtain an estimate for the radius.

\[ \text{radius} \approx \frac{24000 \text{ miles}}{2\pi} \approx 3800 \text{ miles} \]

2.4

You walk from the park to your friend's house, then back to your house.

a) What is the distance traveled?

Just add each distance: park to friend's house = 0.95 mi

friend's house to your house = 0.95 mi + 0.75 mi = 1.7 mi

\[ \Rightarrow \text{total distance} = 0.95 \text{ mi} + 1.7 \text{ mi} = 2.65 \text{ mi} \]

b) What is the displacement?

Displacement is the distance between the starting and ending points, i.e., the distance between the park and your house.

\[ \Rightarrow \text{displacement} = 0.75 \text{ mi} \]

2.16

Estimate how fast your hair grows in miles per hour.

Let's say human hair grows 1 cm in a month. Now convert cm to miles and months to hours.

\[ 1 \text{ cm} \approx 6 \times 10^{-6} \text{ miles} \]

\[ 1 \text{ month} \approx 730 \text{ hours} \]

\[ \Rightarrow \frac{1 \text{ cm}}{730 \text{ hours}} \approx \frac{6 \times 10^{-6} \text{ miles}}{730 \text{ hours}} \approx 1 \times 10^{-8} \frac{\text{miles}}{\text{hour}} \]
(2.18) You jog at 9.5 km/h for 8.0 km, then you jump into a car and drive an additional 16 km. With what average speed must you drive your car if your average speed for the entire 24 km is to be 22 km/h?

average speed = \frac{\text{total distance}}{\text{total time}} = \frac{24 \text{ km}}{T} = 22 \text{ km/h}

\Rightarrow T = \frac{24 \text{ km}}{22 \text{ km/h}} = 1.1 \text{ h is the total time.}

The time it takes to jog is \frac{8.0 \text{ km}}{9.5 \text{ km/h}} = 0.84 \text{ h}.

Therefore it must take 1.1 h - 0.84 h = 0.26 h to drive the 16 km.

\Rightarrow \text{average driving speed} = \frac{16 \text{ km}}{0.26 \text{ h}} = 62 \frac{\text{km}}{\text{h}}

(2.24) \ X(t) = (-5 \text{ m/s}) t + (3 \text{ m/s}^2) t^2

a) Plot \ x \ versus \ t \ for \ t = 0 \ to \ t = 2 \text{s}.

\begin{diagram}
\begin{tikzpicture}
\fill[black!10] (0,0) rectangle (6,4);
\draw[->,thick] (-0.5,0) -- (5.5,0) node[right] {$t \ (\text{s})$};
\draw[->,thick] (0,-1) -- (0,5) node[above] {$x \ (\text{m})$};
\draw (0,0) -- (5,4);
\draw (1,-1) -- (1,1);
\draw (2,-2) -- (2,2);
\draw (3,-4) -- (3,4);
\draw (4,-6) -- (4,6);
\draw (5,-8) -- (5,8);
\end{tikzpicture}
\end{diagram}

b) Find the average velocity from \ t = 0 \ to \ t = 1 \text{s}.

\[ \text{V}_{av_3} = \frac{\Delta x}{\Delta t} = \frac{x_1 - x_0}{t_1 - t_0} \]

\[ x_1 = X(1) = -5(1) + 3(1)^2 = -2 \quad x_0 = X(0) = 0 \]

\[ \Rightarrow \text{V}_{av_3} = \frac{-2 - 0}{1 - 0} = -2 \quad \Rightarrow \text{V}_{av_3} = -2 \frac{\text{m}}{\text{s}} \hat{x} \]

(2) Find the average speed from \ t = 0 \ to \ t = 1 \text{s}.

average speed = \frac{\text{distance traveled}}{\text{time}} = \frac{2 \text{ m}}{1 \text{ s}} = 2 \frac{\text{m}}{\text{s}} = \text{average speed}