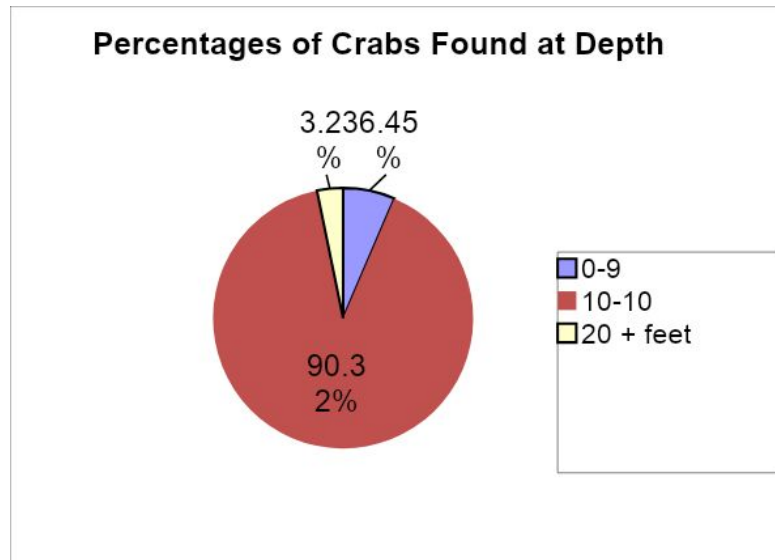


Problem Solving
Scientific Notation
and
Significant Figures

Objectives and Do Now

- Sort raw lab data into an organized table for analysis of patterns or trends
- Determine which type of graph (scatter plot or plot graph) will best represent a set of data
- Plot data on a scatter plot or bar graph with the independent variable as the x-axis
- Record a measurement using all certain digits and one estimated digit
- Determine the number of significant digits that should be recorded in a measurement when given the measuring instrument
- Determine which zeros in a recorded measurement are significant
- Relate the quality of a measuring instrument to the number of significant digits that can be recorded using the instrument

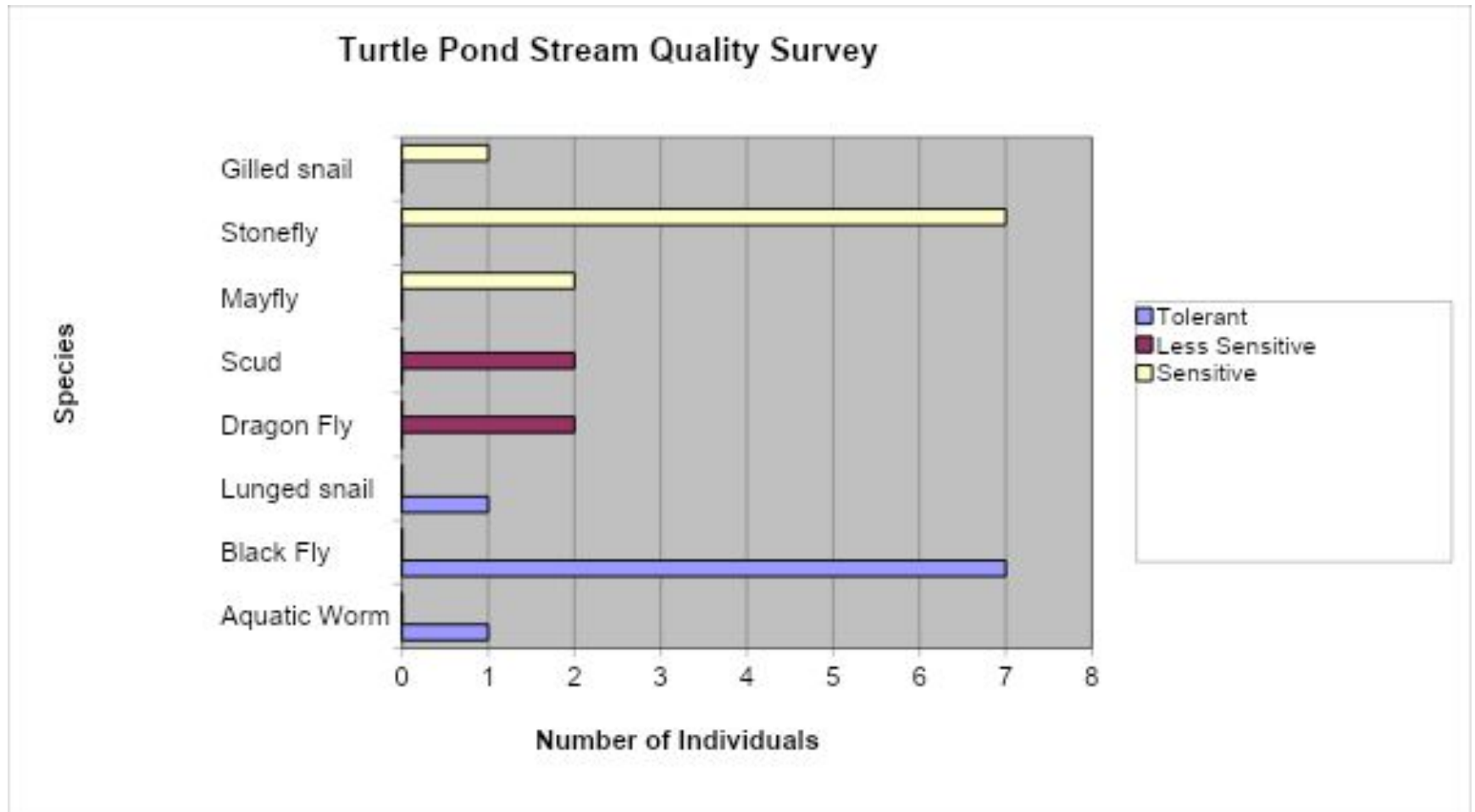
Do NOW – What does this graph represent?



DATA

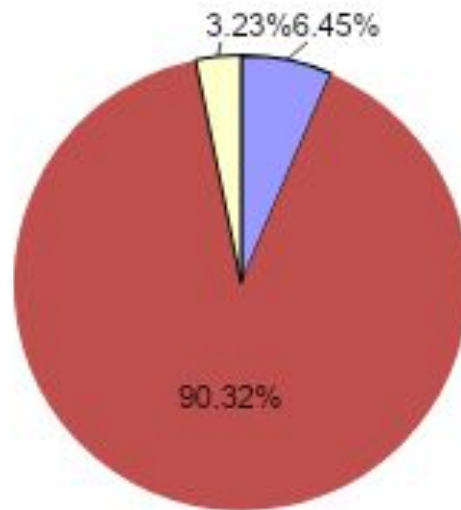
- **Data** (plural) are expressions of values of qualitative or quantitative variables
- Data are typically the results of measurements
- We use visualization them by creating graphs, tables, or images.
- The word *data* is the plural of *datum*

Bar Graphs



Pie Graphs

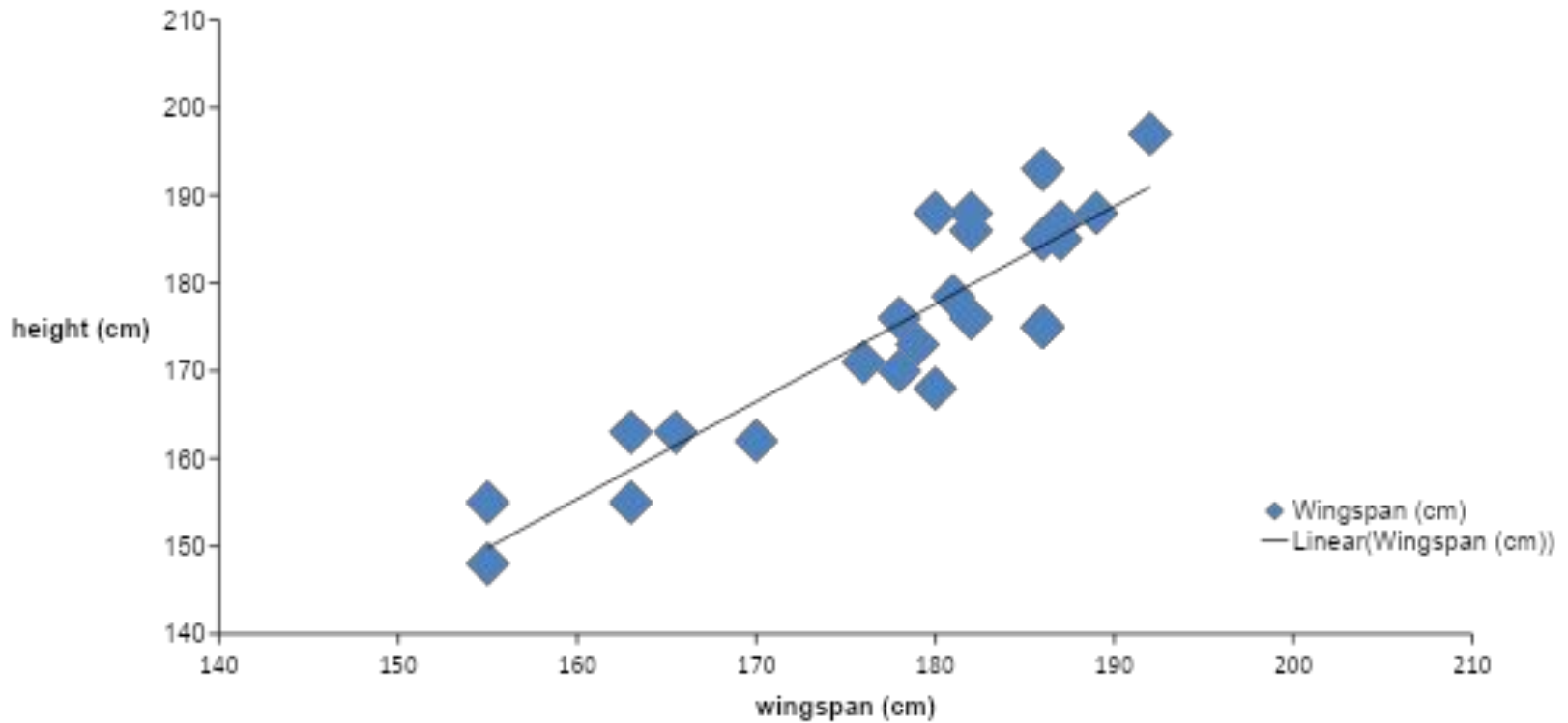
Percentages of Crabs Found at Depth



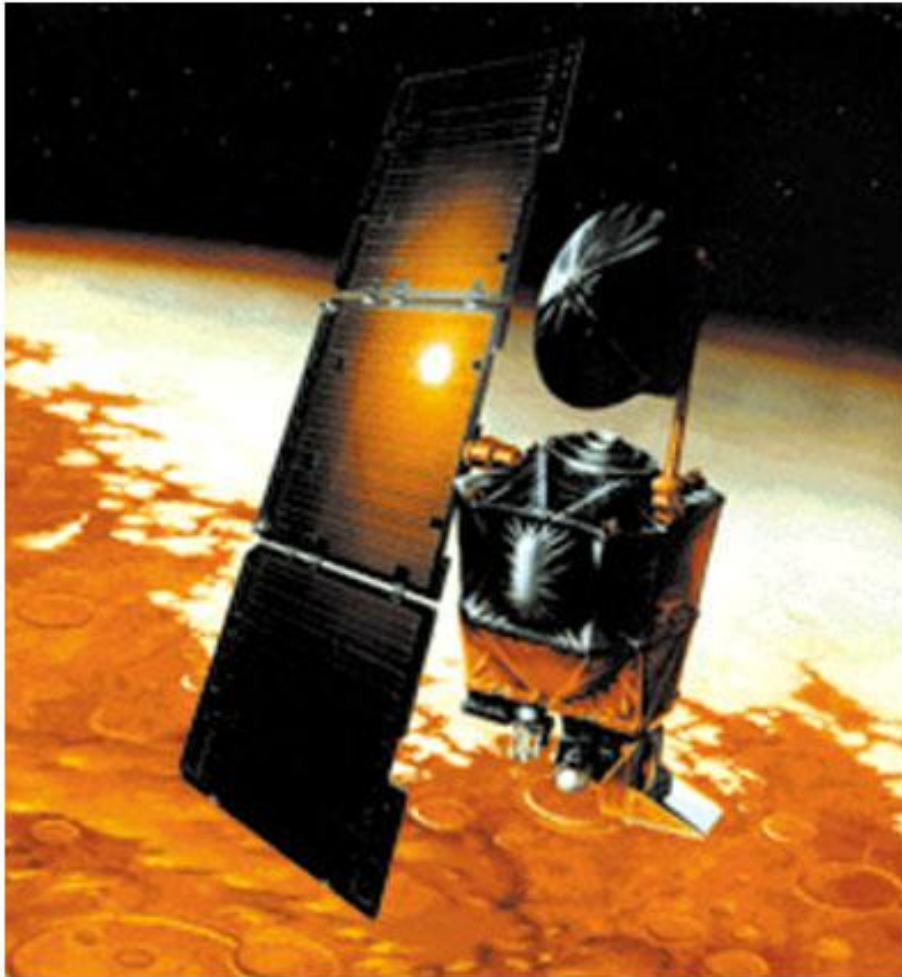
- 0-9
- 10-10
- 20 + feet

Scatter Plots

Correlation of Wingspan and Height



On 9/23/99, \$125,000,000 Mars Climate Orbiter entered Mars' atmosphere 100 km lower than planned and was destroyed by heat.



$$1 \text{ lb} \neq 4.45 \text{ N}$$

“This is going to be the cautionary tale that will be embedded into introduction to the metric system in elementary school, high school, and college science courses till the end of time.”

Stating a Measurement

In every measurement there is a

- ◆ **Number** *followed by a*
- ◆ **Unit from a measuring device**

The number should also be as precise as the
measurement!

Significant figures

- Are digits that express information that is reasonable reliable.
- Accuracy – closeness to the actual
- Precision – detail with which a measurement is known

Rules of Significant Figures

1. All digits 1-9 inclusive are significant
 - Example – 129 = 3 sig figs
2. Zeros between sig figs digits are always significant
 - Example – 5,007 = 4 significant figures

3. Trailing zeros in a number are significant ONLY if the number contains a decimal point

- Example – 100.0 = 4 sig figs
- Example – 100 has 1 sig fig

4. Zeros in the beginning of a number whose only function is to place the number are not significant

- Example – 0.0025 – has 2 sig figs

5. Zeros following a decimal significant figure are significant
- Example – $0.000470 = 3$ sig figs
 - Example - $.47000 = 5$ significant figures

Practice Check

1. 0.02
2. .020
3. 501
4. 501.0
5. 5,000
6. 5,000.
7. 6,051.00
8. 0.0005
9. 0.1020
10. 10,001

Calculating using Significant Figures

- When multiplying and dividing – limit and round the least number of sig figs of any of the factors
- Example
 - $23.0 \text{ cm} \times 432 \text{ cm} \times 19 \text{ cm} = 188,784 \text{ cm}^3$
 - The least amount of sig figs is 19 therefore
 - The answer is $190,000 \text{ cm}^3$

Calculating Sig Figs

- When adding and subtracting, limit and round your answer to the least number of decimal places in any of the numbers that make up your answer
- $123.25 \text{ mL} + 46.0 \text{ mL} + 86.257 \text{ mL} =$
 - 46.0 mL has only one decimal place
 - 255.5 mL is the answer

Practice

1. $1.35 \text{ m} \times 2.467 \text{ m} =$

2. $1,035 \text{ m}^2 / 42 \text{ m} =$

3. $12.01 \text{ mL} + 35.2 \text{ mL} + 6 \text{ mL} =$

4. $55.46 \text{ g} - 28.9 \text{ g} =$

5. $.021 \text{ cm} \times 3.2 \text{ cm} \times 100.1 \text{ cm} =$

UNITS OF MEASUREMENT







Use SI units — based on the metric system
(copy this if you do not know it!)

Measurement	Unit
Length	Meters
Mass	Kilograms
Volume	Liters
Time	Second
Temperature	Celsius Degrees

Metric Prefixes

Prefix	Symbol	Multiplier	
exa	E	10^{18}	1,000,000,000,000,000,000
peta	P	10^{15}	1,000,000,000,000,000
tera	T	10^{12}	1,000,000,000,000
giga	G	10^9	1,000,000,000
mega	M	10^6	1,000,000
kilo	k	10^3	1,000
hecto	h	10^2	100
deka	da	10^1	10
deci	d	10^{-1}	0.1
centi	c	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro	μ	10^{-6}	0.000,001
nano	n	10^{-9}	0.000,000,001
pico micro micro	P $\mu\mu$	10^{-12}	0.000,000,000,001
fermto	f	10^{-15}	0.000,000,000,000,001
atto	a	10^{-18}	0.000,000,000,000,000,001

Metric Prefixes

Height	Volume	Weight
 <p>skyscraper</p> <p>0.35 kilometers 3.5 hectometers 35 dekameters 350 meters 3500 decimeters 35000 centimeters 350000 millimeters</p>	 <p>bottle</p> <p>0.002 kiloliters 0.02 hectoliters 0.2 dekaliters 2 liters 20 deciliters 200 centiliters 2000 milliliters</p>	 <p>cat</p> <p>5 kilograms 50 hectograms 500 dekagrams 5000 grams 50000 decigrams 500000 centigrams 5000000 milligrams</p>
<p>film</p>  <p>0.000035 kilometers 0.00035 hectometers 0.0035 dekameters 0.035 meters 0.35 decimeters 3.5 centimeters 35 millimeters</p>	<p>medicine</p>  <p>0.00002 kiloliters 0.0002 hectoliters 0.002 dekaliters 0.02 liters 0.2 deciliters 2 centiliters 20 milliliters</p>	<p>cherries</p>  <p>0.005 kilograms 0.05 hectograms 0.5 dekagrams 5 grams 50 decigrams 500 centigrams 5000 milligrams</p>

Learning Check

Select the unit you would use to measure

1. Your height

- a) millimeters b) meters c) kilometers

2. Your mass

- a) milligrams b) grams c) kilograms

3. The distance between two cities

- a) millimeters b) meters c) kilometers

4. The width of an artery

- a) millimeters b) meters c) kilometers

Solution

1. Your height

b) meters

2. Your mass

c) kilograms

3. The distance between two cities

c) kilometers

4. The width of an artery

a) millimeters

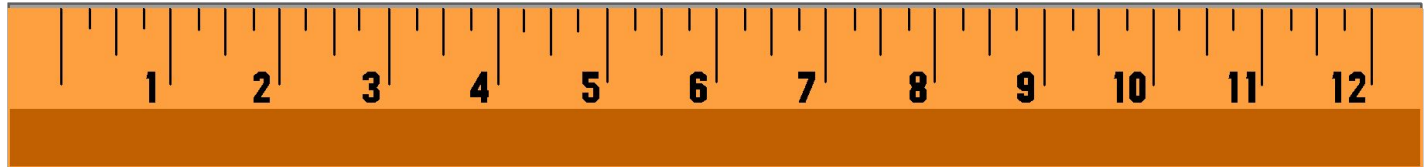
Equalities

AN Equality states the same measurement in two different units

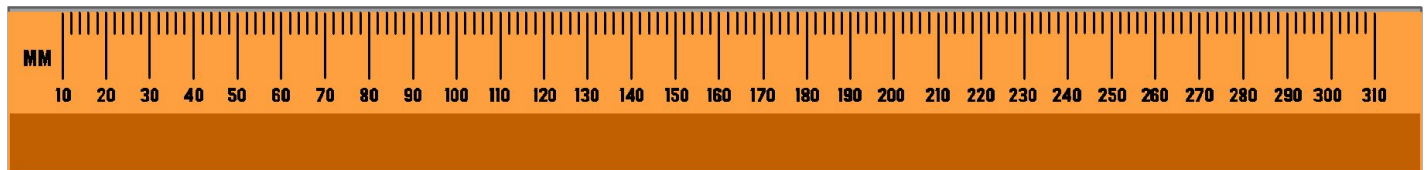
length



10.0 in.



25.4 cm



Conversion Factors

A conversion factor is a fraction in which the numerator and denominator are EQUAL quantities expressed in different units so that when the divided the conversion factor is equal to 1.

Example: 1 in. = 2.54 cm

Factors: $\frac{1 \text{ in.}}{2.54 \text{ cm}}$ and $\frac{2.54 \text{ cm}}{1 \text{ in.}}$

Learning Check

Write conversion factors that relate each of the following pairs of units:

1. Liters and mL
2. Hours and minutes
3. Meters and kilometers

How many minutes are in 2.5 hours?

Conversion factor

$$2.5 \cancel{\text{hr}} \times \frac{60 \text{ min}}{1 \cancel{\text{hr}}} = 150 \text{ min}$$

cancel

By using dimensional analysis / factor-label method, the UNITS ensure that you have the conversion right side up, and the UNITS are calculated as well as the numbers!

Sample Problem

- You have \$7.25 in your pocket in quarters.
How many quarters do you have?

$$7.25 \text{ dollars} \times \frac{4 \text{ quarters}}{1 \text{ dollar}} = \mathbf{29 \text{ quarters}}$$

Learning Check

How many seconds are in 1.4 days?

Unit plan: days \longrightarrow hr \longrightarrow min \longrightarrow seconds

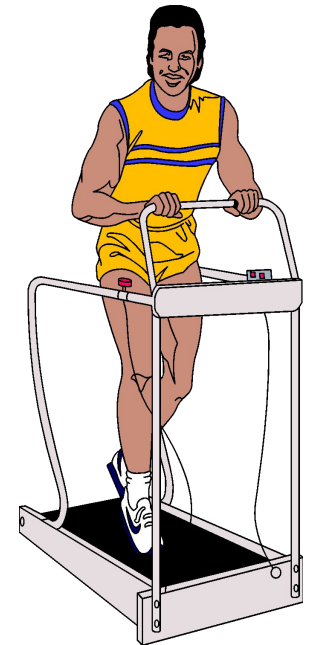
Solution

Unit plan: days \rightarrow hr \rightarrow min \rightarrow seconds

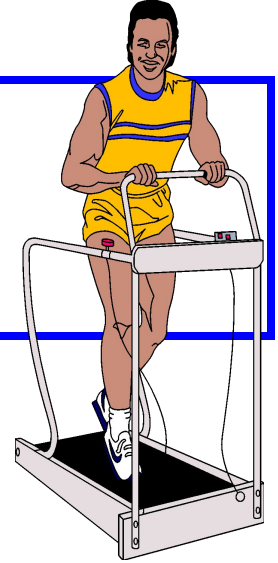
$$\begin{aligned} 1.4 \cancel{\text{ day}} & \times \frac{24 \cancel{\text{ hr}}}{1 \text{ day}} \times \frac{60 \cancel{\text{ min}}}{1 \text{ hr}} \times \frac{60 \text{ sec}}{1 \text{ min}} \\ & = 1.2 \times 10^5 \text{ sec} \end{aligned}$$

Dealing with Two Units

If your pace on a treadmill is 65 meters per minute, how many seconds will it take for you to walk a distance of 8450 feet?



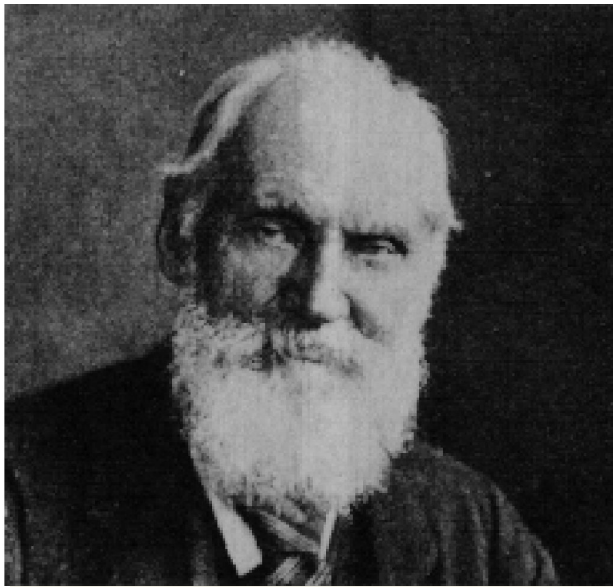
Solution



$$8450 \text{ ft} \times \frac{12 \text{ in.}}{1 \text{ ft}} \times \frac{2.54 \text{ cm}}{1 \text{ in.}} \times \frac{1 \text{ m}}{100 \text{ cm}} \times \frac{1 \text{ min}}{65 \text{ m}} \times \frac{60 \text{ sec}}{1 \text{ min}} = 2400 \text{ sec}$$

Temperature Scales

- Fahrenheit
- Celsius
- Kelvin



Anders Celsius
1701-1744

Lord Kelvin
(William Thomson)
1824-1907

Temperature Scales

Boiling point
of water

Fahrenheit

212 °F

180°F

32 °F

Celsius

100 °C

100°C

0 °C

Kelvin

373 K

100 K

273 K

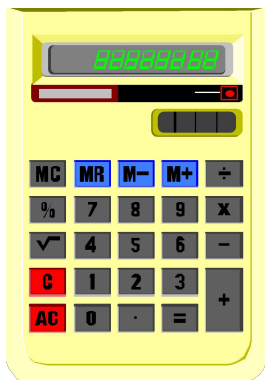
Freezing point
of water

Temperature

- Thermometer measures temperature by the expansion and contraction of a liquid
- Absolute Zero – the temperature at which there is no atomic or molecular motion
- Heat – is the energy that flows from a higher temperature object to a lower temperature object

Concept Check

- When you enter a swimming pool, the water may seem to feel quite cold. After a while though your body “gets use to it,” and the water no longer feels so cold...
- Use the concept of heat to explain what is going on



Calculations Using Temperature

- Generally require temp's in kelvins
- $T \text{ (K)} = t \text{ (}^\circ\text{C)} + 273.15$
- Body temp = $37 \text{ }^\circ\text{C} + 273 = 310 \text{ K}$
- Liquid nitrogen = $-196 \text{ }^\circ\text{C} + 273 = 77 \text{ K}$

Fahrenheit Formula

$$^{\circ}\text{F} = 9/5 \text{ } ^{\circ}\text{C} + 32$$

Celsius Formula

$$(^{\circ}\text{F} - 32) * 5/9 = ^{\circ}\text{C}$$

Temperature Conversions

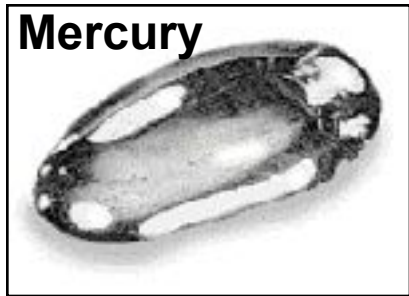
A person with hypothermia has a body temperature of 29.1°C . What is the body temperature in $^{\circ}\text{F}$?

$$\begin{aligned}^{\circ}\text{F} &= \frac{9}{5} (29.1^{\circ}\text{C}) + 32 \\ &= 52.4 + 32 \\ &= 84.4^{\circ}\text{F}\end{aligned}$$

DENSITY - an important and useful physical property

$$\text{Density} = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$$

Mercury



13.6 g/cm³

Platinum



21.5 g/cm³

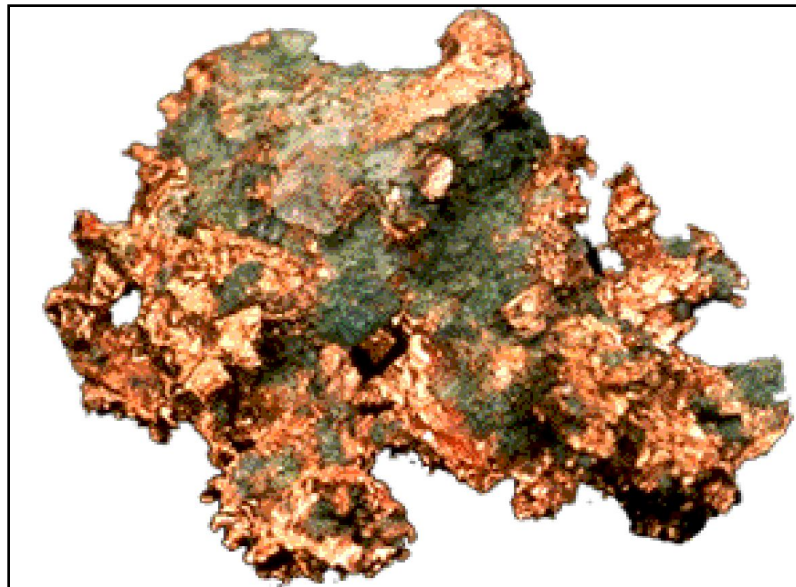
Aluminum



2.7 g/cm³

Problem A piece of copper has a mass of 57.54 g. It is 9.36 cm long, 7.23 cm wide, and 0.95 mm thick. Calculate density (g/cm^3).

$$\text{Density} = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$$



Strategy

1. Get dimensions in common units.
2. Calculate volume in cubic centimeters.
3. Calculate the density.

SOLUTION

1. Get dimensions in common units.

$$0.95 \text{ mm} \cdot \frac{1 \text{ cm}}{10 \text{ mm}} = 0.095 \text{ cm}$$

2. Calculate volume in cubic centimeters.

$$(9.36 \text{ cm})(7.23 \text{ cm})(0.095 \text{ cm}) = 6.4 \text{ cm}^3$$

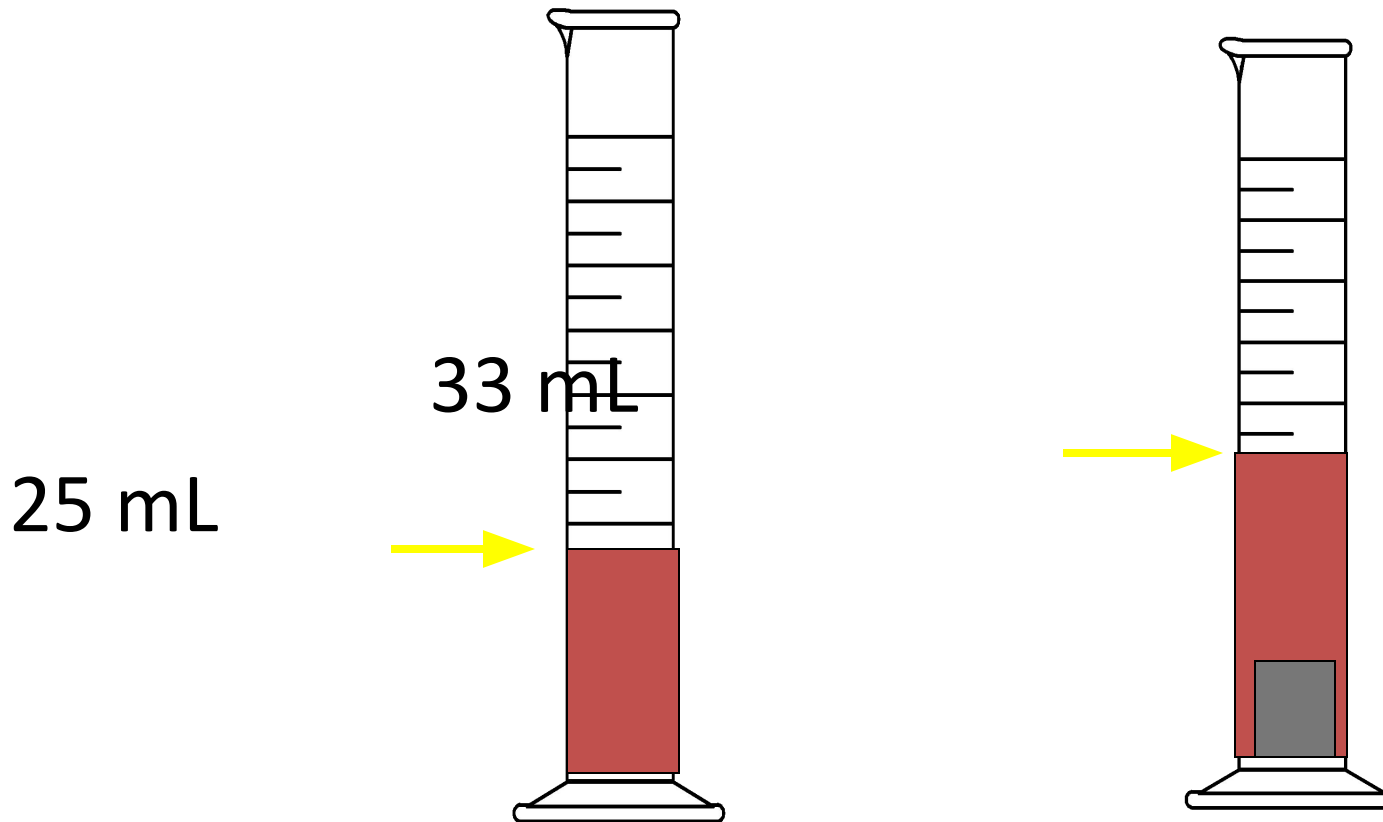
Note only 2 significant figures in the answer!

3. Calculate the density.

$$\frac{57.54 \text{ g}}{6.4 \text{ cm}^3} = 9.0 \text{ g/cm}^3$$

Volume Displacement

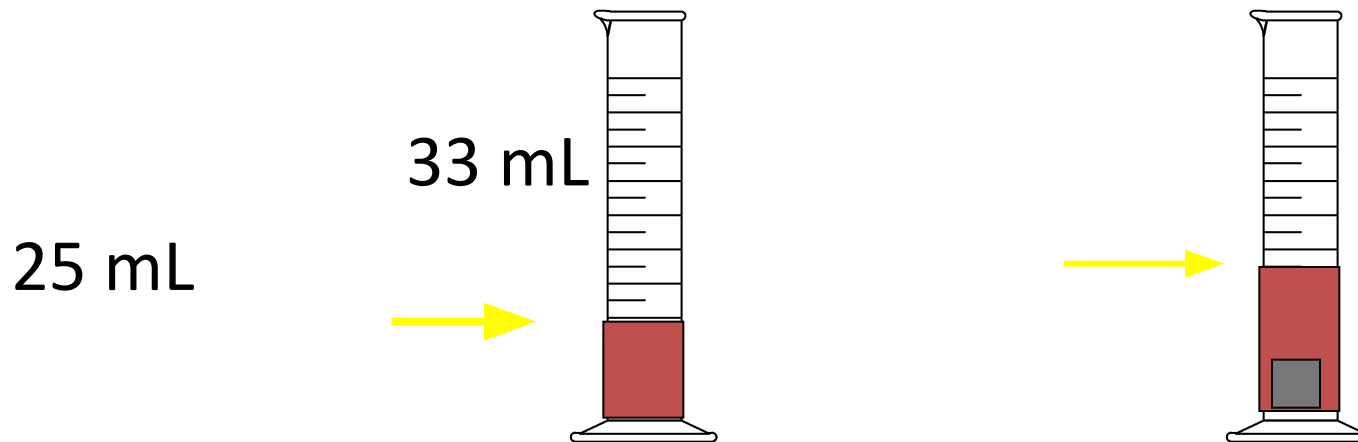
A solid displaces a matching volume of water when the solid is placed in water.



Learning Check

What is the density (g/cm^3) of 48 g of a metal if the metal raises the level of water in a graduated cylinder from 25 mL to 33 mL?

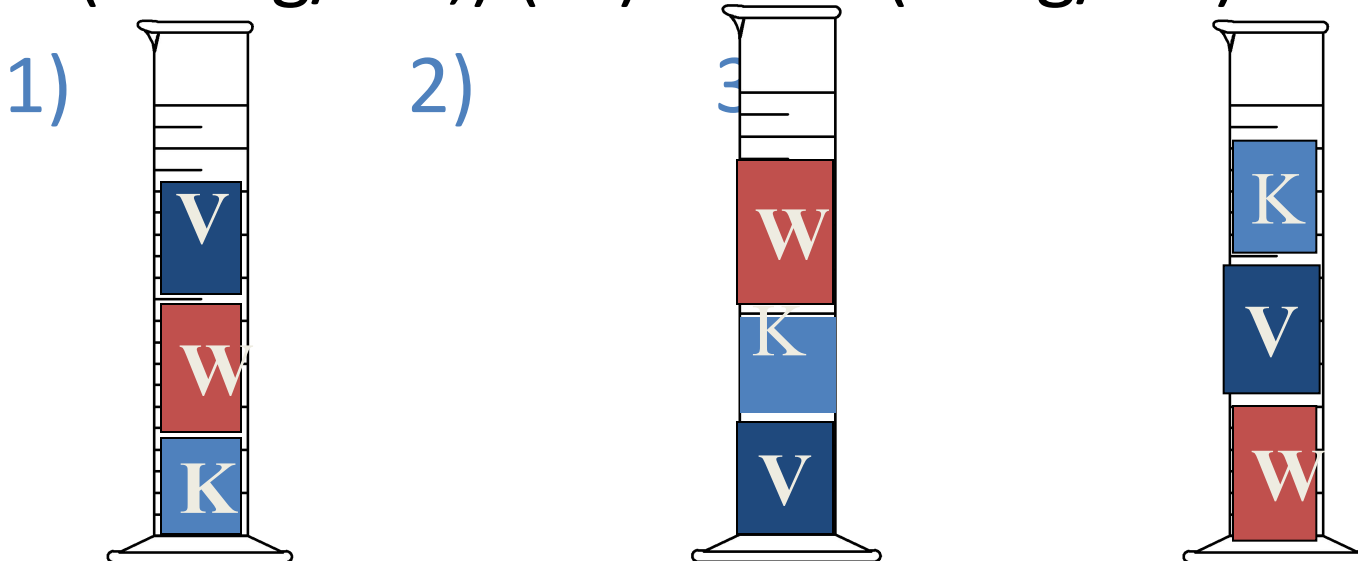
- 1) $0.2 \text{ g}/\text{cm}^3$ 2) $6 \text{ g}/\text{m}^3$ 3) $252 \text{ g}/\text{cm}^3$



Learning Check

Which diagram represents the liquid layers in the cylinder?

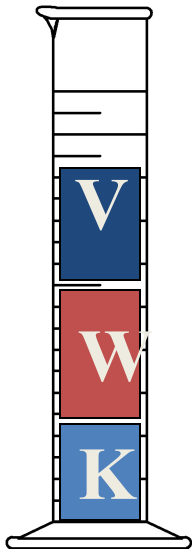
(K) Karo syrup (1.4 g/mL), (V) vegetable oil (0.91 g/mL), (W) water (1.0 g/mL)



Solution

(K) Karo syrup (1.4 g/mL), (V) vegetable oil (0.91 g/mL), (W) water (1.0 g/mL)

1)



Learning Check

The density of octane, a component of gasoline, is 0.702 g/mL. What is the mass, in kg, of 875 mL of octane?

1) 0.614 kg

2) 614 kg

3) 1.25 kg

Learning Check

If blood has a density of 1.05 g/mL , how many liters of blood are donated if 575 g of blood are given?

- 1) 0.548 L
- 2) 1.25 L
- 3) 1.83 L

<i>mega</i>	<i>kilo</i>	<i>hecto</i>	<i>deca</i>	Basic Unit	<i>deci</i>	<i>centi</i>	<i>milli</i>	<i>micro</i>
<i>(M)</i>	<i>(k)</i>	<i>(h)</i>	<i>(da)</i>	Gram (g)	<i>(d)</i>	<i>(c)</i>	<i>(m)</i>	<i>(μ)</i>
1,000,000	1,000	100	10	Liter (L)	.1	.01	.001	.000001
10^6	10^3	10^2	10^1	Meter (m)	10^{-1}	10^{-2}	10^{-3}	10^{-6}

Factor Label Method

- 1. Write the given number and unit***
- 2. Set up a conversion factor***
- 3. Cancel Units and Solve***

Examples

$$55 \text{ mm} = \underline{\hspace{2cm}} \text{ m}$$

$$\frac{55 \text{ mm}}{1000 \text{ mm}} = \frac{1 \text{ m}}{1000 \text{ mm}} = 0.001 \text{ m/mm}$$
$$55 \text{ mm} \times 0.001 \text{ m/mm} = 0.055 \text{ m}$$

Examples

$$88 \text{ km} = \underline{\hspace{2cm}} \text{ m}$$

88 km	1000m	=	88,000 m
<hr/>			
	1 km		

Practice Check

1. 950 g = _____ kg

2. 275 mm = _____ cm

3. 1,000 L = _____ kL

4. 1,000 mL = _____ L

Example with multiple steps

A block of wood 3.0 cm on each side has a mass of 27.0 grams. Find the density.

Example with multiple steps 2

A sample of iron has the dimensions of: 2cm x 3cm x 2cm. If the mass of this rectangular shaped object is 94g, what is the density of iron.

Complete the chart

$^{\circ}\text{C}$ $^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$	$^{\circ}\text{F}$ $^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$
0°C	
	212°F
	98.6°F
-273°C	
	77°F
-40°C	

Closure

- Which of the following states the correct arrangement of data in a scatter plot
 - Dependent variable data is plotted as X and independent data is plotted as Y
 - Independent variable data is plotted as X and dependent data is plotted as Y
- Burets are often used to carefully measure the amount of liquid added to a reaction. The long thin buret tube is marked every millimeter and every tenth of a milliliter – Which of the following measurements is correct for a volume of liquid in a buret?
 - 30 mL
 - 32 mL
 - 32.0 mL
 - 32.01 mL
- Which of the following measurements was recorded to 3 significant figures
 - 30 mL
 - 32 mL
 - 32.0 mL
 - 32.01 mL
- Which of the following measured values has four significant digits?
 - 4500 m
 - 0.045m
 - 0.0045
 - 45.00m
 - 0.450 m
- What are the significant digits in 0.0020750 meters?