Units & Unit Conversion

10/21/2010

Units

What are units?

An accepted quantity used as a standard of measurement. (i.e. – the foot/meter, gallon/liter, and pound/gram)

Why are they important?

Defines the characteristics of an object

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SI vs. English

	The Fundamental SI Units		Most Common English Units	
Physical Quantity	Name of Unit	Abbreviation	Name of Unit	Abbreviation
Mass	kilogram	kg	pound	lb
Length	meter	m	foot	ft
Time	second	s	second	s
Temperature	Kelvin	K	Fahrenheit	° F
Amount of Substance	mole	mol	mole	mol

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A. SI Prefix Conversions

1. **Find the difference between the exponents of the two prefixes.**
2. **Move the decimal that many places.**

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A. SI Prefix Conversions

move left

move right

Prefix	Symbol	Factor
mega-	M	10^{6}
kilo-	k	10^{3}
BASE UNIT	---	10^{0}
deci-	d	10^{-1}
centi-	c	10^{-2}
milli-	m	10^{-3}
micro-	μ	10^{-6}
nano-	n	10^{-9}
pico-	p	10^{-12}

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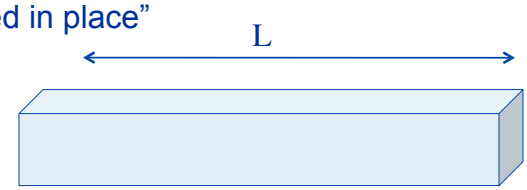
Length

- Define: "the linear extent in space from one end to the other; the longest dimension of something that is fixed in place"



Mass

- Define: the property of a body that causes it to have weight in a gravitational field

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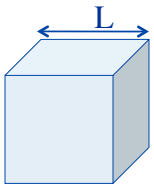
Volume

- Define: "the amount of 3-dimensional space occupied by an object"
- Solid, Liquid, Gas

in^3	ft^3	US gal	Liters	m^3
1	5.787e-4	4.329e-3	1.639e-2	1.639e-5

- Determine Volume of a cube:



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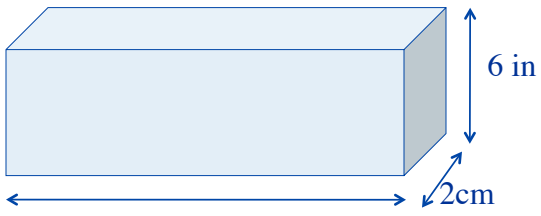
Volume Exercise

- Determine the volume of the following solid:



Exercise Solution with Dimensional Analysis

$$\frac{1.2\,\text{ft}}{}\left|\frac{6\,\text{in}}{}\right|\frac{2\text{cm}}{}\left|\frac{1\,\text{m}}{100\text{cm}}\right|\frac{39.37\text{in}}{1\,\text{m}}\left|\frac{12\text{in}}{1\,\text{ft}}\right| = 68.031\ \text{in}^3$$

$$\frac{68\,\text{in}^3}{}\left|\frac{\text{ft}^3}{12^3\text{in}^3}\right| = 0.03937\text{ft}^3$$

$$\frac{68\,\text{in}^3}{}\left|\frac{1.639\text{e-}5\,\text{m}^3}{1\,\text{in}^3}\right|\frac{100^3\text{cm}^3}{1\text{m}^3} = 1115\ \text{cm}^3$$

Density

- Define: "The density of a material is defined as its mass per unit volume"

$$\rho = \frac{mass}{volume} = \frac{kg}{m^3}$$

- How to determine density with known mass:
  - The amount of volume it displaces in a fluid.
  - Take known amount of liquid (water) in a graduated cylinder
  - Drop solid into water
  - Determine Volume of water with solid in place

$$\rho = \frac{mass}{V_2 - V_1}$$

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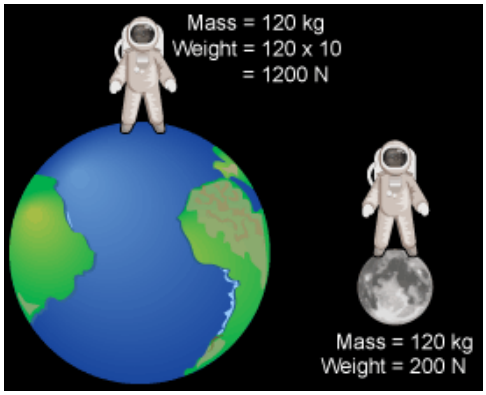
Weight vs. Mass

What is the difference?



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Force

- Force=(mass)*(acceleration)
- What is acceleration?
  - Acceleration equals the change in velocity divided by the change in time.

$$a = \frac{\Delta v}{\Delta t}$$

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Unit of Mass

Weight (Force) = Mass x Acceleration

Force ~ Newtons ~ lbf (.2248 lbf = 1 Newton)

Mass ~ kg ~ lbm or slugs

Acceleration ~ l/time^2

1 lbf = 1 lbm 32.2 ft/s^2 <> 1 Newton = 1 kg 1 m/s^2

1 kg(f) of potato (10 Newton , on earth 9.8 m/s^2)

1 kgf = .1 kg 10 m/s^2

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Supporting slides

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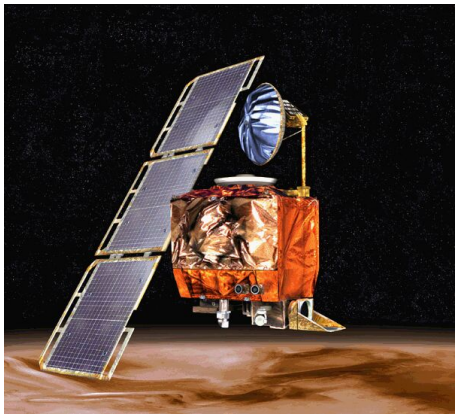
NASA's Mars Climate Orbiter

- **The orbiter crashed into the Martian surface because engineers failed to make a simple conversion from English units to metric, an embarrassing lapse that cost $125 million.**



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B. Dimensional Analysis

- The "Factor-Label" Method
  - Units, or "labels" are canceled, or "factored" out

$$\cancel{cm^3} \times \frac{g}{\cancel{cm^3}} = g$$

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B. Dimensional Analysis

- **Steps:**
  1. Identify starting & ending units.
  2. Line up conversion factors so units cancel.
  3. Multiply all top numbers & divide by each bottom number.
  4. Check units & answer.

B. Dimensional Analysis

- Lining up conversion factors:

$$\frac{1\text{ in}}{2.54\text{ cm}} = 1$$

$$1 = \frac{2.54\text{ cm}}{1\text{ in}}$$

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B. Dimensional Analysis

- **How many milliliters are in 1.00 quart of jet fuel?**

qt → mL

$$1.00\ \text{qt} \times \frac{1\ \text{L}}{1.057\ \text{qt}} \times \frac{1000\ \text{mL}}{1\ \text{L}} = 946\ \text{mL}$$

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B. Dimensional Analysis

- **You have 1.5 pounds of gold. Find its volume in cm^3 if the density of gold is 19.3 g/cm^3.**

lb → cm^3

$$1.5\ \text{lb} \times \frac{1\ \text{kg}}{2.2\ \text{lb}} \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{cm}^3}{19.3\ \text{g}} = 35\ \text{cm}^3$$

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B. Dimensional Analysis

- **How many liters of water would fill a container that measures 75.0 in^3?**

in^3 → L

$$\frac{75.0\ \cancel{in^3} \mid (2.54\ \cancel{cm})^3 \mid 1\ L}{(1\ \cancel{in})^3 \mid 1000\ \cancel{cm^3}} = 1.23\ L$$

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B. Dimensional Analysis

5) **Your European hairdresser wants to cut your hair 8.0 cm shorter. How many inches will he be cutting off?**

cm → in

$$\frac{8.0\ \cancel{cm} \mid 1\ in}{2.54\ \cancel{cm}} = 3.2\ in$$

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B. Dimensional Analysis

6) The Ohio State Buckeyes needs 550 cm for a 1st down. How many yards is this?

cm → yd

$$\frac{550\ \text{cm}}{} \times \frac{1\ \text{in}}{2.54\ \text{cm}} \times \frac{1\ \text{ft}}{12\ \text{in}} \times \frac{1\ \text{yd}}{3\ \text{ft}} = 6.0\ \text{yd}$$

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B. Dimensional Analysis

7) A piece of wire is 1.3 m long. How many 1.5-cm pieces can be cut from this wire?

m → pieces

$$\frac{1.3\ \text{m}}{} \times \frac{100\ \text{cm}}{1\ \text{m}} \times \frac{1\ \text{piece}}{1.5\ \text{cm}} = 86\ \text{pieces}$$

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B. Dimensional Analysis

8) It requires a force of 5 N to start a wagon rolling down a hill. How many pounds force does it take to start the same wagon rolling?

N **lb_f**

$$\frac{5\ \cancel{N} \mid .225\ lb_f}{1\ \cancel{N}} = 1.125\ lb_f$$

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Conservation of Energy

Given:

$$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$$

where →

k = 200 N/m
x = 500 mm
m = 10.0 g

Find: velocity in m/s

$$v = \sqrt{\frac{k}{m}} * x$$

$v = 70.7$ m/s

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