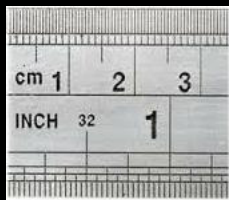
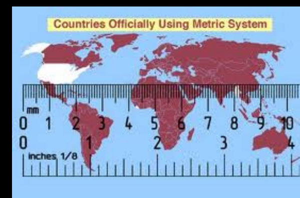


Metric ↔ English



Density

LPT

Metric Conversions

Metric System to English Conversions:

1 inch ≡ 2.54 cm

1 pound = 454 g

1 liter = 1.06 quarts

How many liters of gasoline can a 16 gallon gas tank hold?

$$16.\text{ gal} \times \frac{4\text{ qts}}{1\text{ gal}} \times \frac{1\ \ \text{L}}{1.06\text{ qt}} = 60.37736\text{ L} \rightarrow 60.\text{ L}$$

$$16.0\text{ gal} \times \frac{4\text{ qts}}{1\text{ gal}} \times \frac{1\ \ \text{L}}{1.06\text{ qt}} = 60.37736\text{ L} \rightarrow 60.4\text{ L}$$

$$16.00\text{ gal} \times \frac{4\text{ qts}}{1\text{ gal}} \times \frac{1\ \ \text{L}}{1.06\text{ qt}} = 60.37736\text{ L} \rightarrow 60.38\text{ L}$$

Number of sig figs dictated by initial measurement

LPT

Sig Fig Errors: Source of Disaster

A cargo has a density of 0.84937 kg / L.
What is the mass of 100,000 L?

100,000 L x 0.8 kg / L = 80,000 kg

100,000 L x 0.85 kg / L = 85,000 kg

100,000 L x 0.849 kg / L = 84,900 kg

100,000 L x 0.8494 kg / L = 84,940 kg

100,000 L x 0.84937 kg / L = 84,937 kg

LPT

Metric Conversions

How many liters are in a gallon of milk?

$$1.00 \text{ gal} \times \frac{4 \text{ qt}}{1 \text{ gal}} \times \frac{1 \text{ liter}}{1.06 \text{ qt}} = 3.77 \text{ L}$$

A newborn baby weighs 7.70 pounds. How much drug does the baby receive if the drug dose is 0.147 mg / kg body weight?

$$7.70 \text{ lbs} \times \frac{454 \text{ g}}{1 \text{ lb}} \times \frac{1 \text{ kg}}{1000 \text{ g}} \times \frac{0.147 \text{ mg}}{1 \text{ kg}} = 0.514 \text{ mg}$$

Let the units drive the solution

LPT

Metric Conversions

The weather report lists the barometric pressure as 754.6 mm? What is this pressure in inches?

$$754.6 \text{ mm} \times \frac{1 \text{ m}}{1000 \text{ mm}} \times \frac{100 \text{ cm}}{1 \text{ m}} \times \frac{1 \text{ in}}{2.54 \text{ cm}} = 29.71 \text{ in}$$

A fabric sells for \$ 3.05 per yard. Across the street the same fabric is \$ 3.24 per meter. Which is a better buy?

$$1.00 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} \times \frac{1 \text{ in}}{2.54 \text{ cm}} \times \frac{1 \text{ yd}}{36 \text{ in}} = 1.09 \text{ yd}$$

$$\$\,3.05 / \text{yd} \quad \text{or} \quad \$\,3.24 / 1.09 \text{ yd} = \boxed{\$\,2.97 / \text{yd}}$$

Let the units drive the solution

LPT

Metric Conversions

The biggest piece of fudge ever created weighed 5750. lbs. The recommended serving of fudge is 28g. How many servings did this piece of fudge have?

$$5750. \text{ lbs} \times \frac{454 \text{ g}}{\text{lb}} \times \frac{1 \text{ serving}}{28 \text{ g}} = 9.323 \times 10^4 \text{ servings}$$

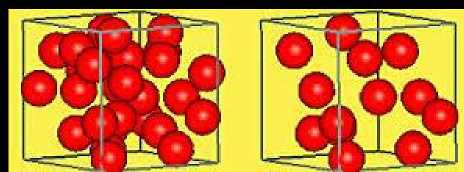
Let the units drive the solution

LPT

Density

Density cannot be measured directly
It must be calculated from mass & volume determinations

Mass: amount of "stuff"
Weight: result of a force (gravity) acting on mass
Density: how much "stuff" per unit volume
Density: measures "compactness"



High Density Low Density

LPT

Density

Density = mass per unit volume
Density : A Derived, not Basic unit

$$\text{density} = \frac{\text{mass}}{\text{volume}} \qquad d = \frac{m}{v}$$

Density is a physical property of substances.

air	0.0012 g/cm^3	Al	2.7 g/cm^3
pine	0.5 g/cm^3	Pb	11.4 g/cm^3
oak	0.8 g/cm^3	Hg	13.6 g/cm^3
water	1.0 g/cm^3	Au	19.3 g/cm^3

Water: ~ 833 times more dense than air

LPT

Example: Find Density

What is the density of copper if 29.4 cm^3 of Cu weighs 265 g?

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Density} = \frac{265\ \text{g}}{29.4\ \text{cm}^3}$$

$$\text{Density} = 9.0136\ \text{g/cm}^3 \rightarrow 9.01\ \text{g/cm}^3$$

MI copper from Isle Royale is one of the world's most pure
Billions of pounds of copper were removed from Isle Royale
MI copper has been found in 5000 year old Phoenician shipwrecks
MI copper considered responsible for the Bronze Age

LPT

Example: Find Mass

What is the mass of 15.7 mL of Hg (density of 13.6 g/mL)?

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \rightarrow \text{Mass} = \text{Density x Volume}$$

$$\text{Mass} = \text{Density x Volume}$$

$$m = \frac{13.6\ \text{g}}{1\ \text{mL}} \times 15.7\ \text{mL}$$

$$m = 213.52\ \text{g} \rightarrow 214\ \text{g}$$

Mercury and all of its compounds are toxic
Mercury is only liquid (at room temperature) metal
Mercury amalgamates (forms alloy) with all metals except iron

LPT

Example: Find Volume

What is the volume of a 46.0 g of Al (density Al = 2.7 g/cm^3)?

Density $= \dfrac{\text{Mass}}{\text{Volume}}$ ➔ Volume $= \dfrac{\text{Mass}}{\text{Density}}$

Volume = Mass / Density

Volume = $\dfrac{46.0 \text{ g}}{2.7 \text{ g/ cm}^3}$

Volume = 17.037 cm^3 ➔ 17 cm^3

Prior to electrical (Hall) refining process:

Aluminum was one of world’s most expensive metals

Napoleon had Aluminum dinnerware

Top of Washington Monument was capped with Aluminum

1855: $ 100,000 / lb 1990: $ 0.74 / lb

LPT

Density Used for Identification

The following are densities for some metals:

manganese	=	7.21 g/cm^3
iron	=	7.87 g/cm^3
nickel	=	8.90 g/cm^3

A piece of wire has a mass of 38.2 g and a volume of 5.30 cm^3.
What is the identity of the metal wire?

Density $= \dfrac{\text{Mass}}{\text{Volume}}$

Density = $\dfrac{38.2 \text{ g}}{5.30 \text{ cm}^3}$

Density = 7.2075 g/cm^3 ➔ 7.21 g/cm^3

Metal ➔ Manganese

LPT

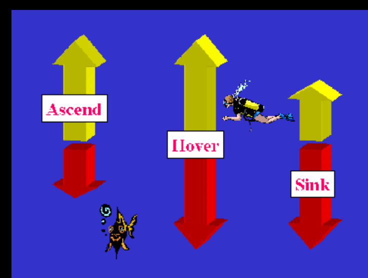
Density: Archimedes Principle

An object partially or wholly immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object

Translation (for water):
objects more dense than water (like lead) will sink
objects less dense than water (like cork) will float
objects of the same density will remain at the same level (hover)

Buoyancy

Weight



LPT

Density: Archimedes Principle

A presumed gold ring has a mass of 2.832 g. When placed in a a 10-mL graduate cylinder , the water level goes from 5.00 mL to 5.15 mL. Is the ring gold (d = 19.3 g/mL) ?

Volume of ring = 5.15 mL – 5.00 mL = 0.15 mL

$$d = \frac{\text{mass}}{\text{volume}} \rightarrow \frac{2.832\ \text{g}}{0.15\ \text{mL}} \rightarrow 18.9\ \text{g / mL} \rightarrow 19\ \text{g/mL}$$

Density slightly less than pure gold, so it is a gold ring with some metal alloy to give it strength.

24k (d= 19.32 g / mL) generally > 99% gold.
24 k too soft for jewelry, so gold jewelry is alloyed for strength
Alloying metals: Ag, Cu, Zn, Ni, Pb, and Pt
14 karat density varies from ~ 12 to 14 g/mL

"karat" value differs from country to country.

LPT

Density: Sink or Float?

Your probe lands on Titan (Saturn moon) to investigate a liquid methane sea (density liquid methane: 422.6 kg / m^3).

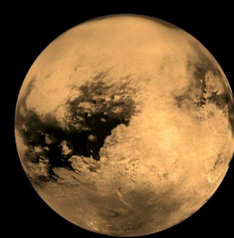
a. Express the methane density as g/ cm^3

$$\frac{422.6\ \text{kg}}{\text{m}^3} \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \ \text{m}}{100\ \text{cm}} \times \frac{1\ \ \text{m}}{100\ \text{cm}} \times \frac{1\ \ \text{m}}{100\ \text{cm}} = 0.4223\ \text{g / cm}^3$$

b. Will your instruments (density 1.53 g / cm^3) sink or float in this sea? Why?

Package is more dense than the fluid, so it sinks.





LPT

Density: Loading Cargo

A boy scout troop has collected 2536 lbs of aluminum soda cans. If the density of the cans is 2.70 g/cm^3, what is the minimum volume needed to transport this material to a recycle center?

$$2536\ \text{pounds} \times \frac{454\ \text{g}}{1\ \text{lb}} \times \frac{1\ \ \text{cm}^3}{2.70\ \text{g}} \times \frac{1\ \ \text{inch}}{2.54\ \text{cm}} \times \frac{1\ \ \text{inch}}{2.54\ \text{cm}} \times \frac{1\ \ \text{inch}}{2.54\ \text{cm}}$$

Continuing (without isolation):

$$\times \frac{1\ \ \text{ft}}{12\ \text{in}} \times \frac{1\ \ \text{ft}}{12\ \text{in}} \times \frac{1\ \ \text{ft}}{12\ \text{in}} = 17.7824\ \text{ft}^3 \rightarrow 17.78\ \text{ft}^3$$


LPT

Density of Water Phases

Liquid water at 4 °C has a density of 1.000 g/mL
Solid water at 0 °C has a density of 0.920 g/mL

What volume will 100. g of water have at these temperatures?

100. g x mL / 1.000 g = 100. mL

100. g x mL / 0.920 g = 109 mL

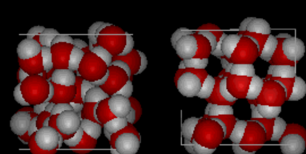
% change:

[(109 – 100) / 100] x 100 = 9 %

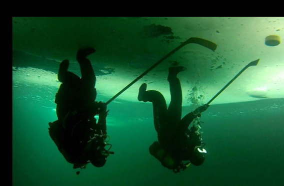
This is why pipes burst
when the water freezes

LPT

Water & Ice



Water Ice



Ice less dense than water, so it floats

Water has maximum density (1.000 g/ml at 4 °C)

If ice did not float, most fresh water critters would not survive winter

Form & Function Are intimately related

LPT

In 1983 Air Canada flight 143 crew manually calculated (Canada was in process of converting to metric system) the volume of fuel needed for a full load of 22,300 kg . They used a density of 1.77 (no units). Turns out the density they used was in units of pounds (not kg) per liter.

Gimli Glider

This is what they did (V = M / D)

$$V = \frac{22{,}300}{1.77} = 1.26 \times 10^4 \text{ liters}$$

They loaded a total 1.26×10^4 liters of fuel.

This is what they should have loaded:

$$22{,}300 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ lb}}{454 \text{ g}} \times \frac{1 \text{ liter}}{1.77 \text{ lb}} = 2.31 \times 10^4 \text{ liters}$$

This Air Canada flight ran out of fuel at 41,000 feet one hour into the flight and glided 20 km (12.4 miles) to a safe landing.

Let the units drive the solution

LPT

Calculations, without units, just don't "look right"

And are often quite wrong!

Let the units drive the solution

LPT