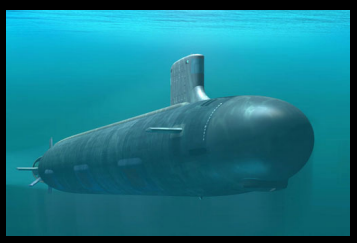
Density



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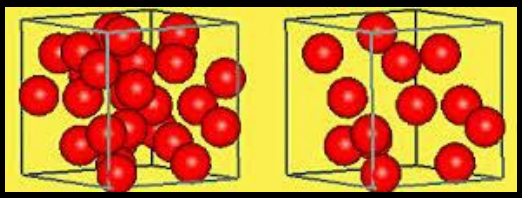
Density

Density = mass per unit volume (density = "per" expression)

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.



A measurement of how much "Stuff" is in a unit volume

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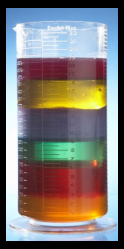
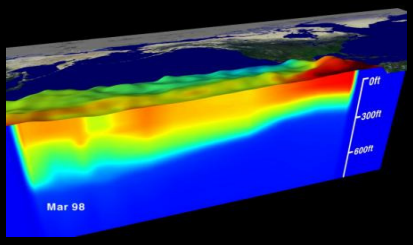
Significance of Density



Fluids Layer Based on Density

- May be based on chemical composition
- Salt water more dense than fresh
- Cold water more dense than warm
- Fluids of different density resist mixing



Moving thru halocline **Water layers by temperature**

Glacial melting is altering Arctic water density-driven-currents
Potential to destroy the Atlantic Gulf Stream (force an Ice Age)

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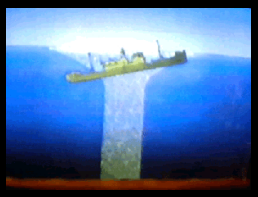
Visible Bubbles Decrease Density of Liquids
(Gases less dense than liquids)



Methane bubbles from volcanic vents, especially in the Mid-Atlantic
Some believe some ship losses can be from encountering "mega-bubbles"

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Star Trek Special Effects: Transporter



Swirling mix of salt water, fresh water, and metallic flakes

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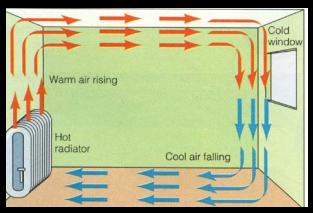
Warm Fluids Typically Less Dense

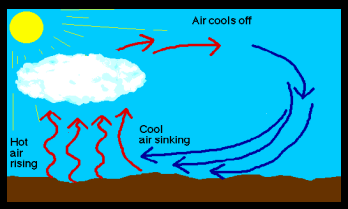
Lava Lamps



Convection Flow

Galileo Air Thermometer

Hot-Air Balloon



Breezes

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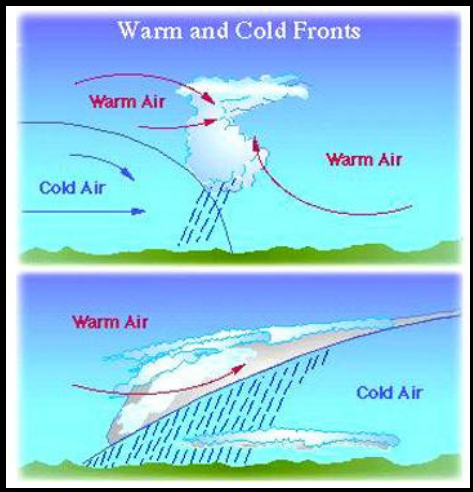
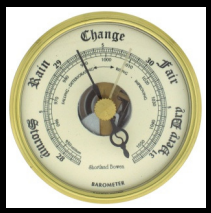
Much of Weather is Conflict Between Air Masses

Cold air more dense than warm air



Fluids of different density
Resist mixing



Barometer

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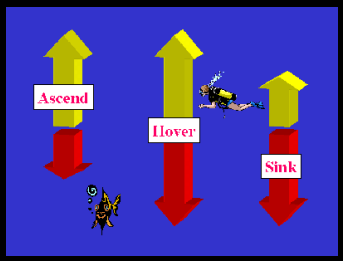
Position in a Fluid

Depends upon Relative density
Buoyancy Moves up
Gravity Pulls Down



Divers, Submersibles, & Water Dwellers
Control depth by altering buoyancy

Hot air balloons, blimps, & dirigibles
Control altitude by altering buoyancy

Archimedes, A Gold Thief, and Buoyancy
http://www-personal.umich.edu/~lpt/archimedes.htm

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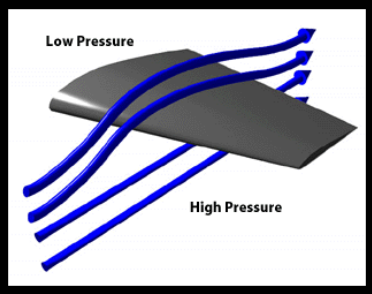
"Lift"

Shape of wing causes rapid air flow on upper surface

Creates density differences above/below wing



Lower density above wing = lift

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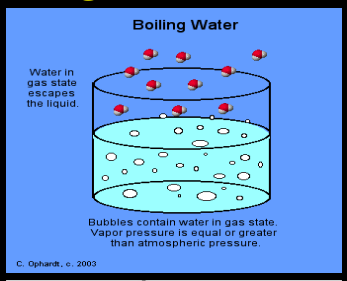
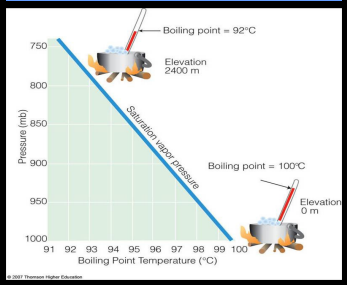
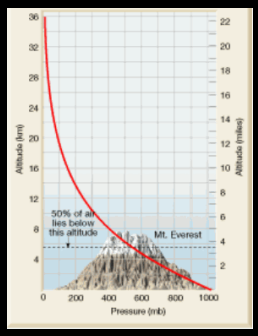
Boiling Point: Function of Weight of Air







At high altitudes:

Boiling point water lower

Cooking temperature less

Food takes longer to cook

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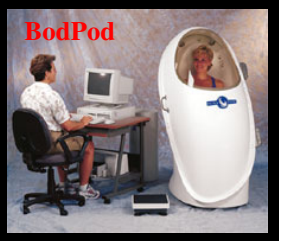
Fat Floats

Weight in-water
Weight out-of-water

Difference ➔ % Body Fat

Fatty tissue less dense than muscle tissue



Michigan: 5th Most Obese State
By 2030, estimated > 60 % MI will be obese
Type II Diabetes now considered an epidemic
Health care costs ➔ trillions

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Sand/Water More Dense than People
Hollywood Horror Movie "Quicksands" Not Likely

Sometimes "Hollywood" is not exactly scientifically accurate

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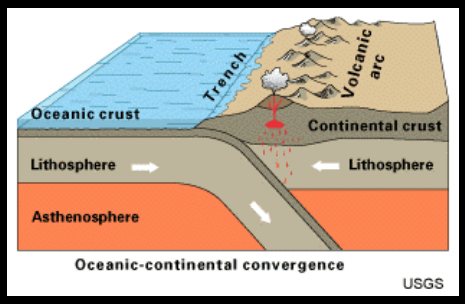
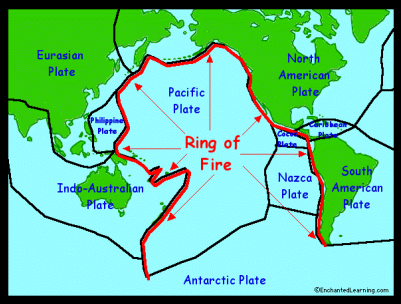
Continental Crust Less Dense Than Oceanic Crust





Earthquakes and Volcanoes:
Driven By Density Differences in Continental Plates

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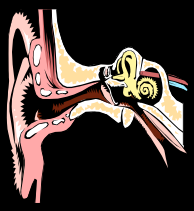
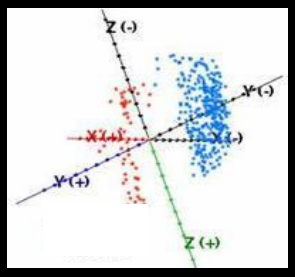
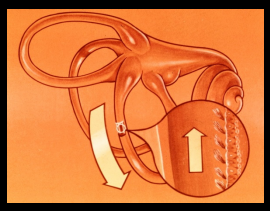
Balance Determined by Fluid Motion in Inner Ear

Alcohol alters density of fluid in semi-circular canals







Inner ear is the last organ in the body to clear alcohol
May take 10-18 hours for alcohol to clear from inner ears

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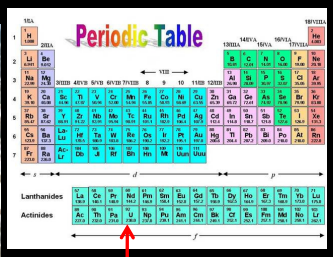
Depleted Uranium Weapons are NOT Nuclear Devices



Uranium

Kinetic Energy = ½ mv^2

Greater density = more momentum on impact

Density (g/mL)

Al = 2.70
Fe = 7.96
Pb = 11.4
Hg = 13.53
U = 19.07
Au = 19.30
Os = 22.67

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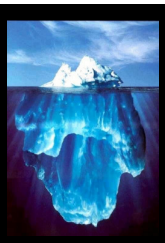
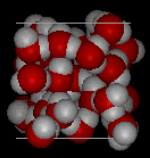
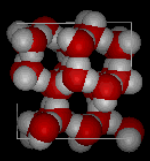
Water & Ice





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

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Relative Density
Controls My Buoyancy!
MAD-MONSTERS.COM
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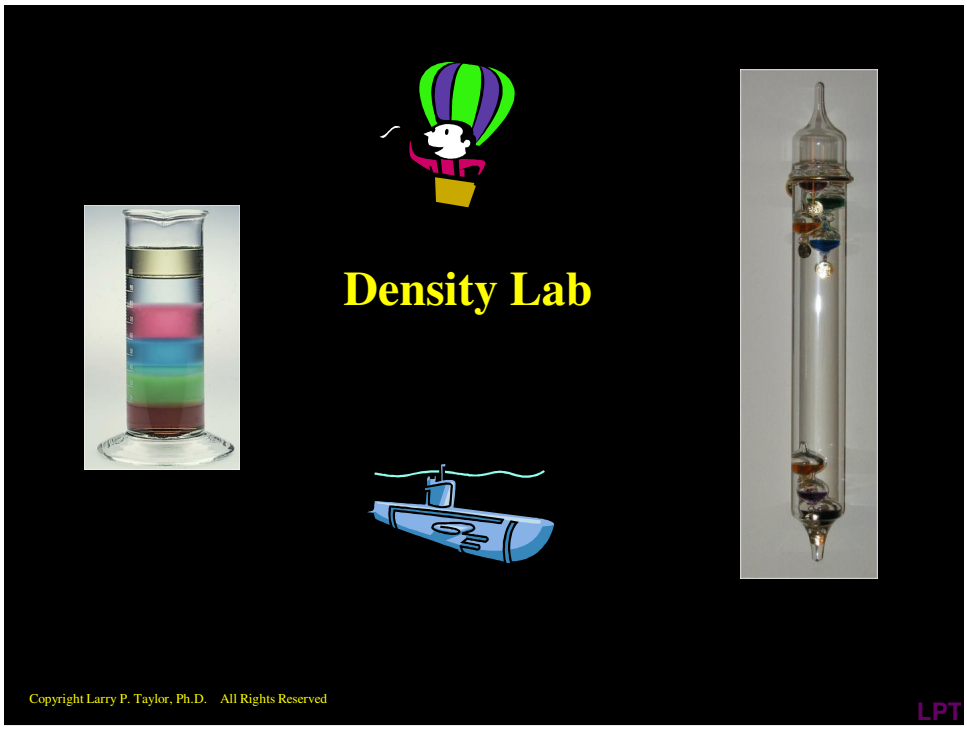
Density Lab
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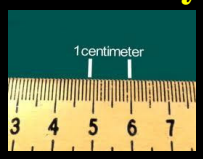
Lab Measurements
Always 1 more digit than measuring device



Distance (cm) measurements: 2 decimal digits

Mass measurements: all decimal digits

Volume (ml) measurements: 1 decimal digit (> 10 mL)
2 decimal digits (10 mL)

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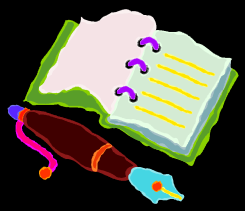
Lab Notebook Measurements

Electronic Devices: Record All Displayed Digits

Non-Electronic Scales: Record 1 decimal digit beyond scale



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Today's Lab (Work in Pairs)

Determine the Density of a Liquid

Each lab pair: use a 10-mL graduated cylinder & a wash bottle

"tare" the balance with graduate cylinder.

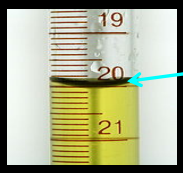
Carefully transfer ~ 1 mL of your liquid to the graduated cylinder

Measure & record the mass & volume of your liquid

Balance: All Digits 10 mL Graduate: 2 decimal places

Repeat 6x, adding about 1 mL each time, until you have ~ 7-8 mL total

Exchange data with the other pair in your group.



Meniscus

Density => Determined by plotting your mass/volume data

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Determine the Density of a Regular Shaped Solid

Use a caliper to measure the diameter of the marble

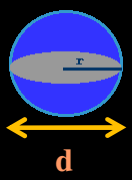
Record dimensions

Measure and record the mass of the object

Caliper gives diameter (d) of the marble

Density = Mass / Volume

Volume of Sphere = $4/3\ \pi\ (d/2)^3$



r = d/2

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Determine the Density of an Irregular Shaped Solid

Measure & record the mass of one of the rocks

Measure / record the volume of water in ~ ½ filled 100 mL graduate cylinder

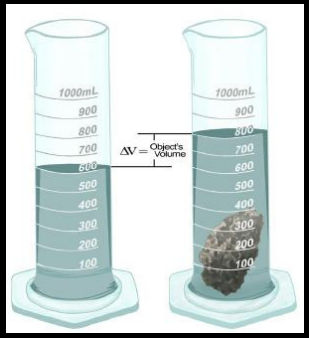
Carefully add the object to the graduated cylinder

Measure and record the new water volume.

Balance: All Digits 100 mL Graduate: 1 decimal places

Density = Mass / Volume

Volume of Object:
Volume of water displaced



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Data:

Record all your measurements

Density of a Liquid

Table: mass & volume for the two liquid samples

Density of a Regular Solid

Record your mass and volume measurements

Density of the Irregular Solid

Record your mass and volume measurements

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Calculations

Determine the Density of a Regular Shaped Solid

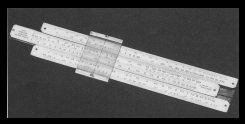
Density = Mass (g) / Volume (mL or cm^3)

Density = Mass (g) / $4/3\ \pi\ (d/2)^3$ (mL or cm^3)

(mL or cm^3 is a derived unit)

Determine the Density of an Irregular Shaped Solid

Density = Mass (g) / Displaced Water Volume (mL)



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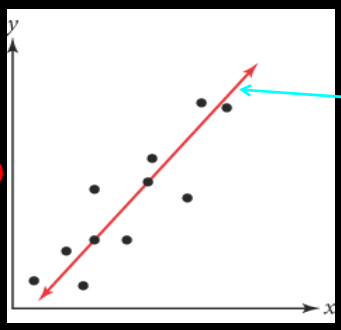
Calculations (Based on Graph Results)

For Density of a Liquid

For each of the 2 liquids,

plot (As a RESULT … use full page) mass vs. volume

Mass (g)



Draw "Best Line" Through your points

One line for each liquid

Volume (mL)

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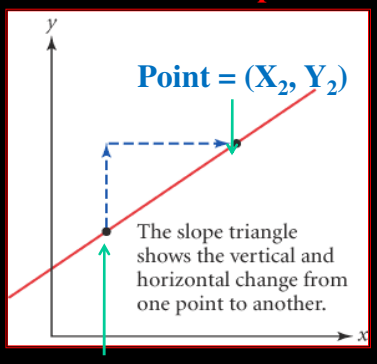
Calculations (Based on Graph Results)

For Density of a Liquid

For each of the 2 liquids,

Determine the slope of each "best" line



$$\text{Slope} = \frac{\text{Change in y axis}}{\text{Change in x axis}} = \frac{(Y_2 - Y_1)}{(X_2 - X_1)}$$

Slope = Mass / Volume

Slope = Density

Point = (X_1, Y_1)

Points from "best" line, not data points

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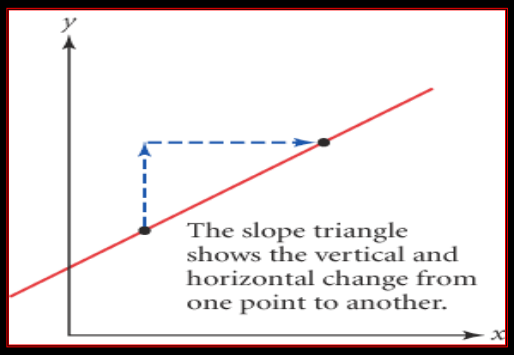
Calculations (Based on Graph Results)



When the plot of two variables gives a straight line, the variables are directly proportional

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Results

Tabulate the densities you calculated for each sample
Graph Your Density Data

Conclusion

Does graphical data imply that mass and volume are directly proportional?

Which of the two liquids studied is more dense ?

Infer the identity of your unknown solid

Rock Sample Densities:

Magnetite	5.00 g/mL
Basalt	3.00 g.mL
Granite	2.90 g/mL

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Let's Boldly Go Explore Today's Lab

LPT