

Density

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Density

Density = mass per unit volume (density = "per" expression)
 Density = A Derived, not basic unit

$$\text{Density} = \frac{\text{mass}}{\text{volume}} \quad D = \frac{m}{v}$$

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**

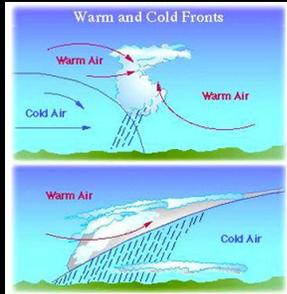
Hot-Air Balloon **Breezes**

Galileo Air Thermometer

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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

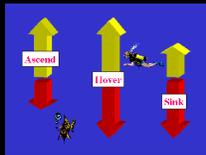


Barometer

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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>

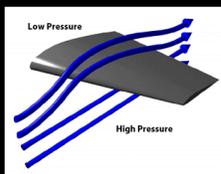
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“Lift”

Shape of wing causes rapid air flow on upper surface

Creates density differences above/below wing

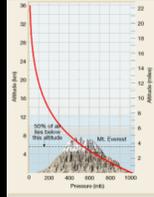
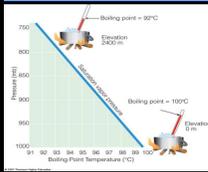
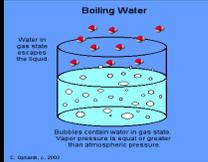


Lower density above wing = lift

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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

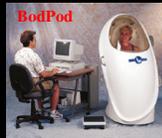
Weight in-water
Weight out-of-water

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



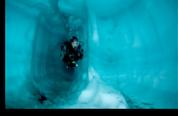
Sometimes "Hollywood" is not exactly scientifically accurate

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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!




M89-M015 ERS.COM

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Density Lab



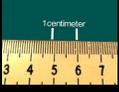




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Lab Measurements

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

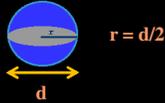
Measure and record the mass of the object



Caliper gives diameter (d) of the marble

Density = Mass / Volume

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



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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 ~ 1/2 filled 100 mL graduate cylinder

Carefully add the object to the graduated cylinder

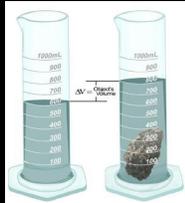
Measure and record the new water volume.

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

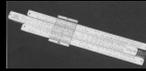
Determine the Density of a Regular Shaped Solid

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

(mL or cm³ is a derived unit)

Determine the Density of an Irregular Shaped Solid

$$\text{Density} = \text{Mass (g)} / \text{Displaced Water Volume (mL)}$$



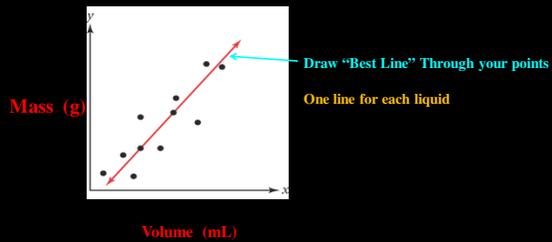
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Calculations (Based on Graph Results)

For Density of a Liquid

For each of the 2 liquids,
plot (As a RESULT ... use full page) mass vs. volume



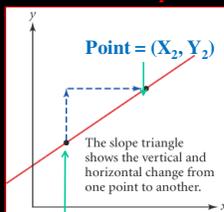
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Calculations (Based on Graph Results)

For Density of a Liquid

For each of the 2 liquids,
Determine the slope of each "best" line



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

$$\text{Slope} = \text{Mass / Volume}$$
$$\text{Slope} = \text{Density}$$

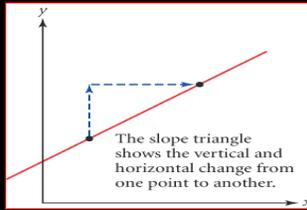
Point = (X₁, Y₁)

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



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