LOWELL OBSERVATORY
Camps for Kids
(LOCKs)

Science Challenge

Driving Question	What is my density?
Grade group	4th grade +
Safety Considerations	Make sure an adult is there with you if you want to measure your own volume. Completely submerging yourself poses a risk of drowning. **Note:** it is NOT advised to measure a cat's volume using the Archimedes Principle (from someone who tried).
Materials	Measuring tape or ruler Calculator Pencil paper Food scale Bathroom scale Rectangular box Ball string Various irregular shaped objects from around that house that can get wet without being ruined. Water (several liters) Large bowl Measuring cup(s) Baking tray (make sure the bowl can fit in the baking tray) Bathtub Extra bucket Tape
Standards:	**5.P1U1.1** Analyze and interpret data to explain that matter of any type can be subdivided into particles too small to see and, in a closed system, if properties change or chemical reactions occur, the amount of matter stays the same. **5.P1U1.2** Plan and carry out investigations to demonstrate that some substances combine to form new substances with different properties and others can be mixed without taking on new properties

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	5.MD.C Geometric measurement: Understand concepts of volume and relate volume to multiplication and to addition.
Vocabulary	**Mass (m)** - the quantity of matter which a body contains, usually given in kg **Area (A)** - the size of a surface, given by the product of length and width, usually given in m^2 **Volume (V)** - the amount of space that an object occupies, given by the product of area and height, usually in m^3 **Density (ρ)** - the amount of mass per unit volume, or mass divided by volume, usually given in kg/m^3

Lesson Objective: The purpose of this challenge is to learn about mass, volume and density, and apply these concepts to measure the density of irregular shaped objects.

Schedule:
Day 1-2: Acquire the materials needed for this experiment. Most objects can be found lying around the house. Perform experiment.
Day 3-4: Send in results to LOCKs Facebook page.

Instructions:

1. First gather all supplies from around the house.
2. You'll want to use the food scale to measure the weight of all the objects. It's easiest if your scale has a metric setting, otherwise you can use the table below to convert from standard units to metric. **Mass** is usually measured in kg or g. Pick a unit and stick with it! Write down the mass of all the objects. *Note: mass and weight are not the same, but for the purposes of this experiment, they can be used interchangeably.*
3. Using a ruler, measure the length of all the sides of the rectangular box. Length is usually measured in m or cm. Use the formula for the **volume of a rectangular prism** to find the volume of the box. All formulas needed are given below in a table. A volume of a liquid is usually measured in ml or L, while the volume of a solid is usually measured in cm^3 or m^3 (cubic centimeters or cubic meters).

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4. To measure the volume of a sphere, we will have to take some extra steps. First use the string to measure the circumference of the ball around its middle. Use the formula below to find the **radius** of the ball. With the radius, you can use the formula for **volume of a sphere** to find the volume.
5. Find the volume of other objects using the Archimedes Principle. The Archimedes Principle states that *an object submerged in water will displace the volume of water equal to the volume of the object.* First, place the bowl on the baking sheet. Make sure the baking sheet is big enough to catch any spilled water from the bowl. Then, fill the bowl with water to the rim, making sure to measure just how much water goes in it. Submerge the object completely in the water, letting the water spill over the sides into the baking sheet.
6. Pour the water from the baking sheet into a measuring cup to find its volume. You'll have to do some math to convert L to cm^3. There is a table of unit conversions below to help you out with this.
7. Once you have found the volume of all the objects you want to find volumes of, divide the mass of each object by its volume to get its density. **Density** is usually given in units of g/cm^3 (grams per cubic centimeters) or kg/m^3 (kilograms per cubic meter).
8. Now is the fun part. This part can be done next time you have bath time. You'll make sure you have an adult with you to help you out and stay safe. Using the bathroom scale, find out your weight. People in the US use pounds to measure weight. To convert to kilograms, multiply your weight by 0.4536.
9. Fill the bathtub more than you would normally, by 2 or 3 inches more. Before you get in, however, you need to mark the height of the water in the tub, either with tape or marker. Then, get in the tub. You'll see the water rise up. If you're brave enough, you can go all the way under, and have an adult mark the height that the water level rises to.
10. There are two suggested methods of getting your volume.
    a. you can assume the tub is a perfect rectangular prism and measure the length, width and height of the water, then measure the height it rises to. You'll take $(l \times w \times h_{before}) - (l \times w \times h_{after})$ to get the volume displaced. This is YOUR volume!
    b. Another longer but more accurate method would be to take out the water that was displaced until the water level is at the first mark again. Make sure to use a measuring cup to count (and keep track of) how much is being removed in the process. You can do whatever you like with this water.

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11. Finally, find your density by dividing your weight by your volume. Use the table in the link below to see how dense you are compared to other everyday things!

Resources:

A Handy Unit Conversion Table
https://www.isa.org/uploadedFiles/Content/Training_and_Certifications/ISA_Certification/CCST-Conversions-document.pdf

A Unit Converter
https://www.calculator.net/conversion-calculator.html

A Table of Densities of various objects
https://www.thoughtco.com/table-of-densities-of-common-substances-603976

Area and Volume Formulas
https://www.nova.edu/tutoring-testing/study-resources/forms/area-and-volume-formulas.pdf

Taking it Further! Did you know that Saturn has a density of 0.687 g/cm^3? That's less dense than water, meaning it would float if you could get a bathtub big enough! How do we measure the density of a planet? You'll have to do some extra digging and research, but when you find the answer, you should tell us what you got!

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A Glossary of Math Symbols

b : base h : height w : width l : length r : radius π : "pi" ≈ 3.14	m : mass w : weight C : circumference A : area V : volume ρ : "ro" the symbol for density	g : gram kg : kilogram oz : ounce lb : pound mL : milliliter L : liter	cm : centimeter m : meter in or " : inch ft or ′ : foot

Formula Chart

Radius of a Circle $r = \frac{C}{2\pi}$	**Area of a Rectangle** $A = lw$	**Area of a Circle** $A = \pi r^2$
Volume of a Rectangular Prism $V = lhw$ or $V = Ah$	**Volume of a Sphere** $V = \frac{4}{3}\pi r^3$	**Density** $\rho = \frac{m}{V}$

Unit Conversion Charts

Volume

mL	L	g/cm^3	$gallons$
1	0.001	1	0.002642
1000	1	1000	0.2642
3785.41	3.78541	3785.41	1

Weight/Mass

g	kg	oz	lb
1	0.001	0.03527	0.0022
1000	1	35.2739	2.2046

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28.3495	0.02835	1	0.0625
453.592	0.4536	16	1

Length

cm	m	in	ft
1	0.01	0.3937	0.0328
100	1	39.37	3.28
2.54	0.0254	1	0.0833
30.48	0.3048	12	1