

Hy-Density: An Exploration of Hydrodensitometry

Activity 3B

NOTE: If your students have sufficient background in measuring mass and volume and know how to calculate density, they may skip some of the developmental activities and proceed directly to Part 6 on simulating hydrodensitometry.

Activity Objectives:

Part 1 – Hy-Density: The Golden Crown

After reading a fictional story, students will be able to:

- describe the problem-solving strategy used by Archimedes
- describe their own scientific process

Part 2 – Hy-Density: Just Staying Afloat (Buoyancy)

Using common materials, triple beam balance, and graduated cylinders, students will be able to:

- observe the buoyancy of various homogeneous objects
- combine two or more materials to observe the buoyancy of heterogeneous objects
- make inferences based upon their observations
- measure mass and volume

Part 3 - Hy-Density: Equal Arm Balance

Using simple materials, students will be able to:

- make an equal arm balance
- explain the difference between mass and weight

Part 4 – Hy-Density: Archimedes Follow-Up

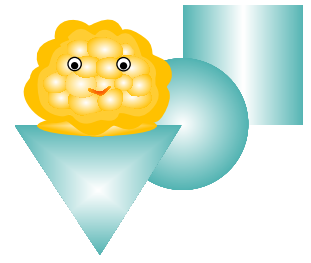
Using simple materials, students will be able to:

- develop their own scientific process and then evaluate the validity of that process
- design an experiment based on the story of Archimedes and the Golden Crown
- draw a data table and collect data
- draw conclusions based upon analysis of the data

Part 5 – Hy Density: Calculating Density of Homogeneous and Heterogeneous Materials

Using common materials, students will be able to:

- calculate density
- describe the relationship among density, mass, and volume
- calculate density of homogeneous and heterogeneous materials



Activity Overview



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Part 6 – Hy-Density: It’s a Stick! It’s Clay! No, It’s Denso Man!

Using common materials, students will be able to:

- explain how adding simulated fat and muscle tissue affects density
- explain how hydrodensitometry can be used to determine body composition
- define *homogeneous* and *heterogeneous* and relate these terms to their own bodies
- collect, record, and analyze data
- draw conclusions based upon analysis of data

Activity Description:

Hydrodensitometry is the “Gold Standard” for determining body composition. In our time, one of the greatest health risks facing people is obesity. However, defining obesity is not as simple as it might seem. Many people would say that standing on the bathroom scales and reading the number is the way they measure obesity. What makes the issue more complex than that is the fact that two people weighing 200 pounds may differ greatly in their body composition and overall health. One may be a body builder, in whom much of his/her body weight is due to muscle, while the other may be a “couch potato” in whom much of his/her body weight is fat tissue. It is really a matter of how much fat and fat-free mass they have. When the percentage of fat increases and fat-free mass decreases a person can become obese.

This activity is not focused on obesity per se, but on body composition and how it can be measured. Knowing that most teachers do not have an underwater weighing tank in their room and that there are sensitivity issues involved in teaching adolescents about body composition, a simpler way for students to learn about the method that is considered one of the more accurate methods for determining fat and fat-free masses in an individual.

Lesson Activity Sequence:

Part 1—Hy Density: The Golden Crown

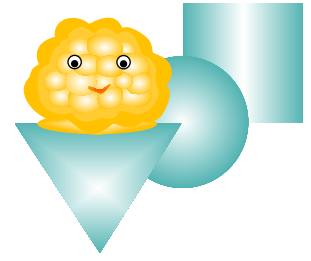
- Science, Math and Language Arts activity
- Fictionalized account of historical event
- Contemporary introduction to Archimedes
- Design to build creative frustration to lead students to find out what they don’t know—teachable moments on the way!

Part 2—Hy Density: Just Staying Afloat (Buoyancy)

- Science
- Observation of the buoyant nature of homogeneous and heterogeneous materials

Part 3—Hy Density: Equalizing Matters (Equal Arm Balance)

- Science and Historical Technology
- Build an Equal Arm Balance similar to one used during Archimedes time



Activity Overview Continued



Part 4—Hy Density: Archimedes Revisited

Science, Math and Historical Technology

Using an Equal Arm Balance students look at mass

Using an Equal Arm Balance students look at mass in water

Observation of the buoyant nature of homogenous and heterogeneous materials

Part 5—Hy Density: Alike and Different

Science and Math

Calculating the density of homogeneous and heterogeneous materials

Part 6—Hy Density: Hydrodensitometry of Denso Man & Denso Woman

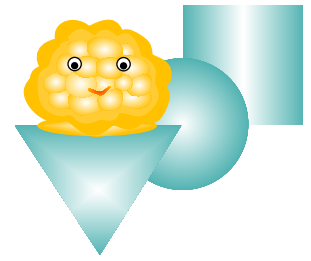
Science and Health

Determining the density of a model made of materials that represent the fat and fat-free masses in the human body

Activity Materials: (for 10 groups of 3-4 students for all parts of the activity)

(If your students are familiar with the supporting background, some parts of the activity may be skipped. Set up a material bin for each group and you will have materials needed for any or all parts of this activity.)

- ◆ 10 bins large enough to hold all materials
- ◆ 20 clear plastic cups
- ◆ 10 aluminum pie pans
- ◆ 10 graduated cylinders of each - 50 mL and 100 mL
- ◆ 10 metric rulers with binder holes
- ◆ 10 pair of scissors
- ◆ 30 Plastic Drinking Straws
- ◆ 10 sandwich size plastic bags with a Ziploc™ on them
- ◆ 10 triple beam balances (students can share if 10 balances are not available)
- ◆ 30 large paper clips
- ◆ 200 – 300 wooden craft sticks—found at craft store; 80/class of 32 students
- ◆ 10 – 30g pieces of wax; sheets of dental wax are best if you can get some from a local dentist; 5 sheets/class of 32 students
- ◆ 10 – 50g pieces of non-toxic/odorless/non-hardening modeling clay (do not buy colored clay), such as Permoplast™ Modeling Clay
- ◆ WATTS 42143912®; found in plumbing section at hardware store
- ◆ Tape to label the bags
- ◆ Dull knife and a cutting board to cut the clay



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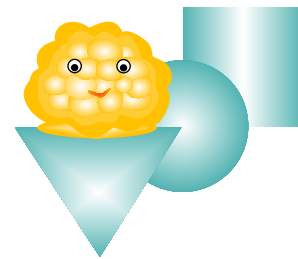
- ◆ 1 3cm or 4 cm piece of vinyl tubing
 - For all kits, you will need: 10 ft -7/8" (outside diameter) x 5/8" (inside diameter) clear vinyl tubing cut as follows:
 - 3cm pieces
 - 4cm pieces
- ◆ 1 *"lump of solid gold"* made of aluminum foil and 1 penny
 - For all kits you will need 2-3 boxes of aluminum foil
 - 10 pennies or a metal coins that have a greater density than aluminum foil
- ◆ 1 Dry Erase Marker (for teacher use only)

Suggestions for miscellaneous items

- ◆ 10 pair of tongs
- ◆ 10 thermometers
- ◆ Weight set of objects, such as washers, of known mass
- ◆ Any thing else you would like to add, such as metal washers or metal BB's

TEACHER PREP: (DON'T LET THE STUDENTS SEE YOU DO THIS!)

1. Into each bin place two clear plastic cups and one of each material listed. Add only a 3cm vinyl tube *or* a 4cm tube in each bin. Place any other objects you want, depending on your school lab supplies.
2. Get the aluminum foil and pennies. You are going to add one penny to a ball of aluminum foil. Start with a penny then wrap aluminum foil around it until you can form a ball about the size of a golf ball. Form a tight ball. This is the *"lump of gold"* discussed in the story.
3. Place the golf-ball size aluminum foil (with the penny in it) on a triple beam balance. Determine the mass. Place that *"lump of gold"* into the plastic bag.
4. Start adding loose sheets of aluminum foil to the balance until it has the same mass as the *"lump of gold"*. Add enough aluminum foil so that the balance shows an equal mass to your *"lump of gold"*. This second amount of aluminum foil is for the students to make a *"crown"*.
5. Place the material for the *"crown"* in the same plastic bag as the *"matching" "lump of gold"*.
6. Repeat procedures 2-5 until all bins have a plastic bag with the *"gold"* and material for the *"crown"*.
7. Using one of the rulers measure the diameter of the *bottom* of one of the plastic cups. This will be the diameter of the *"crown"* the students will make. *You need to write this diameter on the board.*



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Activity References Used:

Heymfield SB, Lohman TG, editors, **Human body composition**. 2nd ed. Champaign: Human Kinetics; 2005.

DURNIN JV. TAYLOR A. **Replicability of measurements of density of the human body as determined by underwater weighing**. [Journal Article] *Journal of Applied Physiology*. 15:142-4, 1960 Jan.

Ferrera, Linda A. (editor). **Body Mass Index** New York: Nova Biomedical Books, 2005

MB Snijder, RM van Dam, M Visser and JC Seidell. **What aspects of body fat are particularly hazardous and how do we measure them?** *International Journal of Epidemiology* 2006;35:83–92

The American Heritage® Dictionary of the English Language, Fourth Edition

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Suggested Websites:

Background information on Archimedes

<http://www-history.mcs.st-andrews.ac.uk/history/Mathematicians/Archimedes.html>

<http://www.mcs.drexel.edu/~crorres/Archimedes/Crown/CrownIntro.html>

<http://www.math.nyu.edu/~crorres/Archimedes/contents.html>

Inventions of Archimedes

<http://www.math.nyu.edu/~crorres/Archimedes/contents.html>

Archimedes Principle

<http://www.onr.navy.mil/focus/blowballast/sub/work2.htm>

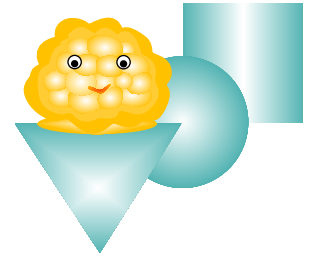
Interactive Pan Balance to use online

<http://illuminations.nctm.org/ActivityDetail.aspx?id=33> interactive pan balance students can use on-line

Making a Pan Balance

<http://www.sciencetoymaker.org/copter/balance.htm>

<http://www.labsafety.com/refinfo/ezfacts/ezf121.htm>



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Buoyancy/density demonstrations
<http://www.middleschoolscience.com/>

<http://www.terrificscience.org/ncw/pdf/Cartesian%20Divers.pdf>

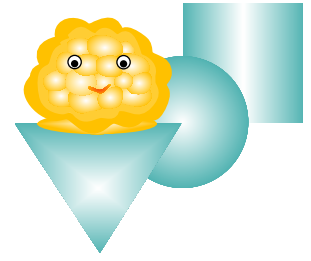
<http://www.grow.arizona.edu/Grow--GrowResources.php?ResourceId=200>

<http://www.onr.navy.mil/focus/blowballast/sub/work2.htm>

Density of Common Metals
<http://www.coolmagnetman.com/magconda.htm>

Hydrodensitometry Site
<http://nutrition.uvm.edu/bodycomp/uww/>

Geotechnical Rock and Water Resources website:
<http://www.grow.arizona.edu/Grow--GrowResources.php?ResourceId=200>



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