Matter in Reaction (Part 1 of 2):

[Adapted from *NASA's Museum in a Box*]
A teacher demonstration.

What is it?

Things are not always what they seem! Just because two things look alike may not mean that they are alike. NASA uses density to its advantage by building low-density (e.g. light) shuttle tiles. Students will have a chance to handle a shuttle tile included in this kit.

In this activity, students will discover that two bowling balls are different densities, causing them to behave differently in water.

This activity discusses topics related to National Science Education Standards:

MS-PS2-2: *Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.*

- Students will calculate the volume of displaced water in this activity using the forces at work in the system.

Materials (per class):

Equipment, provided by NASA:

- 66-quart water container (this kit's container)
- 2 Bowling Balls (one weighing less than 12 pounds and one weighing more than 12 pounds)

Materials (per team of 2 to 4 students)

Consumables, not provided by NASA:

- String
- Scratch Paper

Equipment, not provided by NASA:

- Ruler/Meter Stick
- Calculator
- Scale

Printables:

- Buoyancy Force Worksheet

Artifact included in this kit:

- Shuttle Tile and Information Sheet (***DO NOT REMOVE THE PLASTIC!*** Shuttle Tiles are not safe to handle without a plastic cover)

Recommended Speakers from Ames:
Please note that our Speakers Bureau program is voluntary and we cannot guarantee the availability of any speaker. To request a speaker, please visit http://speakers.grc.nasa.gov.

Dean Kontinos (Hypervelocity Air and Space Vehicles)

Ernie Fretter (Arc-Jet, Re-entry Materials)

Mark Mallinson (Space, Satellites, Moon, Shuttle Technology)

Set-Up Recommendations:

- Prepare copies of the **Buoyancy Force Worksheet**.
- Fill the clear container to about 2/3 full with water
- Lay out the scratch paper for each of the students.

Procedure:

1. Introduce the activity: When a bowling ball is lowered into the container of water, it has a downward motion (because of gravity pulling it into the center of the Earth, although dampened by the teacher slowing that motion). The ball eventually stops moving, but why? There is an upward force on the ball, which is a result of the balls weight (mass) and density. Students will predict whether bowling balls will float or sink in a container of water. We recommend breaking students into teams of 2 to 4. Pass out the **Buoyancy Force Worksheet** to teams.
2. Ask students whether the bowling ball will sink or float in the water. They can write their team's hypothesis on the **Buoyancy Force Worksheet**.
    a. *Optional Extension: Keep a tally on the board of how many students will think it will sink and how many think it will float.*
3. Carefully place one of the bowling balls in the water (you can decide whether you which ball to use first). **Do not drop the bowling ball into the container!**
4. Ask students if they think the same thing should happen again with the second bowling ball. [Optional: take a second tally of the students' guesses.]
5. Have students hypothesize about the reason one ball sank and one ball floated.
6. Place each ball on the scale. Students should be able to see that one ball has a mass of more than 12 pounds and the other has a mass less than 12 pounds.
7. Now that the students know the bowling balls have different weights, ask them why that would be important for one to sink and one to float. Work with them to an understanding that the density of the water must be in between the two bowling balls.
8. Together as a class, calculate the density of the bowling balls. You can decide whether you would like the students to work together in their teams though the calculations, or write the calculations up on the board. All of the density calculations can be found on the **Buoyancy Force Worksheet**.

9. Pass around the shuttle tile. Students should notice that it feels a lot lighter than they may have thought. Talk with them about how the density of the shuttle tile is less than other tiles you see here on Earth. The reason for this is so that NASA can reduce the weight of the Space Shuttle before it is launched into space.

Helpful Resources:

NASA's Gas Density:
http://www.grc.nasa.gov/WWW/k-12/airplane/fluden.html

Information about NASA's Shuttle Tiles:
http://spaceflight.nasa.gov/shuttle/reference/shutref/orbiter/tps/hrcitiles.html

ehow.com Explaining Density to Students:
http://www.ehow.com/how_7706125_explain-density-elementary-students.html

Safety:

- If you are using a glass container, please be sure to not drop the bowling balls into it! It will shatter the glass!
- Shuttle Tiles are NOT to be handled without any protective coating (our samples are enclosed in plastic). DO NOT REMOVE THE PLASTIC!

Names: ____

Buoyancy Force Worksheet

1) What do you think will happen when your teacher places the first bowling ball in the tank of water?

2) Describe what happened when the first bowling ball was placed in the tank of water.

3) Describe what happened when the second bowling ball was placed in the tank of water.

4) Why do you think this happened? What forces are at work in this system?

5) You will now calculate the approximate volume of displaced water by each bowling ball using the forces in this system.

    a) Your teacher will measure the mass each bowling ball. If your scale measures in pounds, convert from pounds to kilograms.

b) Now, calculate the force of gravity on each bowling ball using F=m*g, where *m* is the mass (in kilograms) of the bowling ball and *g* is the acceleration of gravity, or 9.8 meters/seconds^2. Your answer should be in Newtons (or *N*).

c) Calculate the volume of each bowling ball using the following equations:

Circumference = $2 \times \pi \times r$, where π is 3.14159 and *r* is the radius of the bowling ball
Volume = $(4/3) \times \pi \times r^3$

e) Calculate the volume of displaced water by each bowling ball using the following equation:

$F = g\rho V$, where *F* is the buoyant force, *g* is the acceleration of gravity, ρ is the density of water (or 1,000 kg/m^3), and *V* is the volume of the displaced water. *Hint: Remember that the force of gravity is acting constantly on the bowling ball, even though it is not moving.*

Matter in Reaction (Part 2 of 2):
[Adapted from *NASA's Museum in a Box*]

What is it?

Things are not always what they seem! Just because two things look alike may not mean that they are alike. In this activity, students will learn about the properties of matter and how those properties can change. By placing a burning candle in an inverted jar over a trough (pie tin) of water, students can observe (through the changes in water level) the density of the air increase as the jar heats up and watch it contract as the air cools down.

This extension on a classic candle-in-a-jar demonstration adds temperature and density components to the activity.

This activity discusses topics related to National Science Education Standards:

MS-PS1-4: *Develop a model that predicts and describes changes in particle motion temperature, and state of a pure substance when thermal energy is added or removed.*

- This activity analyzes water levels before and after a burn period, which changes the density of the air in the system, allowing students to *see* that a reaction has occurred within the system.

Materials (per class):

Equipment, not provided by NASA:

- Matches **(to only be handled by an adult)**
- *Optional: Food Coloring*

Materials (per team of 2 to 4 students):

Equipment, provided by NASA:

- Clear Jar

Equipment, not provided by NASA:

- Spacers (such as coins) to place jar on in trough
- Candle

Consumables, not provided by NASA:

- Pie Tin

Materials (per student):

Printables:

- Air in a Jar Worksheet

Artifact included in this kit:

- Shuttle Tile and Information Sheet (***DO NOT REMOVE THE PLASTIC!*** Shuttle Tiles are not safe to handle without a plastic cover)

Recommended Speakers from Ames:

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Dean Kontinos (Hypervelocity Air and Space Vehicles)

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Mark Mallinson (Space, Satellites, Moon, Shuttle Technology)

Set-Up Recommendations:

- Prepare copies of the **Air in a Jar Worksheet**.
- Fill the pie tin about 2/3 full with water, adding food coloring if desired.

Procedure:

1. Introduce the activity: when chemicals react with one another, there are signs of that reaction. Burning, for example, changes the chemical composition of a material, but it can also change material *around* that reaction.
2. **Safety Moment:** Adults will be handling the matches for the candles. Students are not to touch the flame.
3. We recommend breaking students into teams of 2 to 4. Pass out the **Air in a Jar Worksheet** to teams. Have students answer question 1) on the worksheet.
4. Place the candle in the water, securing the candle so that it doesn't tip over. Place a few counts around so that the jar is raised up from the bottom of pie tin.
5. Have an adult (or yourself) go around and light the candle. Place the jar on the coins, making sure the jar is sealed with water.
6. Ask students to observe both the candle burning and the water level as the candle burns, then extinguishes. Have students note the water bubbles that appear as the water in the jar heats up. They can record their observations on their **Air in a Jar Worksheet**.
7. [Optional: You can repeat this demonstration several times, if necessary in order for students to have a chance to develop a hypothesis about the rising water level, bubbles, etc.]
8. Explain to the students what is happening: One may think that the water level is rising inside of the jar because the oxygen is being used up, causing a constant change in density in the air. This is not the case. Instead, the candle flame causes the air in the jar to increase in temperature. The hotter air is actually expanding inside of the jar (lower density), and trying to escape through the water. When the flame extinguishes, the water level rises because the air is

beginning to cool and contracts (higher density), pulling up water into the space it leaves behind.

9. At the end of class, have the students answer the rest of the questions on the **Air in a Jar Worksheet**.

Helpful Resources:

NASA's Gas Density:
http://www.grc.nasa.gov/WWW/k-12/airplane/fluden.html

Information about NASA's Shuttle Tiles:
http://spaceflight.nasa.gov/shuttle/reference/shutref/orbiter/tps/hrcitiles.html

ehow.com Explaining Density to Students:
http://www.ehow.com/how_7706125_explain-density-elementary-students.html

Safety:

- This activity contains an open flame and matches. Please practice safe procedures when dealing with the open flame.
- Students should not drink the water in the pie tin.
- Shuttle Tiles are NOT to be handled without any protective coating (our samples are enclosed in plastic). DO NOT REMOVE THE PLASTIC!

Names: ____

Air in a Jar Worksheet

1) What do you think is going to happen? Why?

2) Write and/or draw a picture to show what is happening during the demonstration. Add as many details as possible about the candle, the flame, and the water.

3) Explain what happened during the demonstration.

4) Based on your instructor's explanation, why did that occur?

5) Did that support or contradict your pre-lab explanation? How so?

6) Think of another demonstration or experiment you would like to try that would test the results of this experiment. What would you do? How would you test and/or challenge the results of the experiment you just took part in?