BEAM Lesson Plan

Lesson Name: A lesson on density &/or pressure
Lesson Type: Module
Target: Elementary School/High School
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Introduction:
To explain density, the key idea is something more dense will be heavier in the same amount of space (volume) as another item. It would be a good idea to bring some sort of example that the students would be able to feel in their hands (i.e. a large marshmallow vs. a rock of the same size, a medium balloon vs a lead brick, styrofoam person vs. real person)

Each module is designed to approach density from a different angle while showing something fun and entertaining to the students. Some of these modules can also be explained by pressure, you can use either explanation. I think for the high schools, the modules relating to pressure might be better, especially the PV = nRT reasoning. You do not have to do all of them, feel free to pick and choose the modules that you think would work best for your site. I put a time estimate for each module so plan accordingly.

Modules & Materials: (per module)
Cartesian Diver (~15 minutes)

- Eye Droppers
- Plastic Water Bottle (mentors bring their own)

Density Column (~20 minutes)

- Sugar
- Food Coloring
- Table spoon of similar sized item
- Clear Cups

Dancing Raisins (~10-15 minutes)

- Raisins
- 7-up or Sprite or clear soda
- Clear Cup

Crushed Can (~15-20 minutes)

- Soda Can (possibly from the dancing raisins!)
- Hot Plate
- Container of water
- Tongs

Egg in a Bottle (~15 minutes)

- Glass Bottle
- Hard-boiled egg
- Matches, paper (kindle)

Solar Balloon (~30-40 minutes)

- Solar Balloon
- Rubber Band
- Cotton String

Directions:

Cartesian Diver (~15 minutes)

Background: The cartesian diver is an eyedropper in a plastic water bottle filled with water. Initially the dropper is floating but then the water bottle is squeezed, the diver begins to "dive" (sink). The reason is because the air inside the dropper that gets condensed when the bottle is squeezed. When the air condenses, the density of the dropper increases, causing it to sink.

Step 1:
Fill plastic bottle full with water. Fill the dropper part-way so that it floats but will sink when bottle is squeezed. This may take some fiddling until the right balance is achieved. Play with diver! Yay! DO NOT TURN UPSIDE DOWN because the air inside dropper will escape and you'll have to "reset" the diver.

Density Column (~20 minutes)

Background: The density column is just a long, clear cylindrical container with various liquids of different colors and densities to make something of a rainbow effect. In our density column, we will only be using water and different amounts of sugar with different color dyes (out of convenience). The idea is that although some things are the same volume, they can be more massive (heavier), i.e. density. The sugar solution at the bottom stays that way because it is denser, etc.

Step 1:
Dissolve 1, 2, 3, & 4 tablespoons of sugar into 3 tablespoons of water each, respectively. Add a drop of different food coloring in each one and mix. (I would suggest blue for densest, then red, green and yellow)

Step 2: Using the cup with 4 tablespoons of sugar as the base, slowly add in the solution with 3 tablespoons being careful not to disturb the denser solution. Repeat with remaining colors. (Note, the column won't last long because of diffusion, work this into the lesson plan if you want)

Dancing Raisins (~10-15 minutes)

Background: The dancing raisins demo is just raisins in a cup with 7-up or Sprite poured into cup. As the carbonated beverage release CO_2, some of it forms on the raisins and causes them to rise. Once the raisin reaches the surface, the bubbles pop and the raisins fall back down. The up and down movement of the raisins constitute the "dancing".

Explanation: As bubbles form on the raisins, the volume of the raisin increases with a negligible increase in mass, therefore the density of the raisin decreases to the point where it is less dense than the soft drink and floats.

Step 1:
Place small handful of raisins (maybe about 10 pieces) into clear plastic cup. Pour in the clear carbonated beverage. Watch as magic ensues.

Crushed Can (~15-20 minutes)
Background: The crushed can demo is when a can is crushed by a vacuum caused by the quick condensation of water vapor inside the can. When the can is heated with water inside, the water begins to boil and the air inside is slowly replaced with water vapor. When the can is turned upside down into cold water, the water vapor inside quickly condenses which creates a vacuum that crushes the can.

This trick can be explained two different but complementary ways: density & pressure.
Density: The water inside the bottle is heated so that some of it evaporates as vapor which takes up a larger volume than liquid water, once the water condenses, it takes up less room and a vacuum is created.
Pressure: The inside of the can has a much lower pressure than outside the can once the water condenses which causes the walls of the container to close in to create a smaller volume (PV = nRT).

Step 1:
Empty and rinse the aluminum can, fill part way with water (~2 tablespoons). Set aside a bowl filled with cold water on the side.

Step 2:
Heat the can on the hot plate until you see steaming. Now wait a little longer to insure that the entire can is mostly water vapor. Using tongs, quickly lift and flip the can upside down into the bowl of cold water, it should crush instantly.

Egg in a Bottle (~10-15 minutes)
Background: The egg in a bottle trick is a very simple demo. In case the solar balloon does not work, this may be used as the “main” demo. The trick involves sucking a hard-boiled egg that just barely covers the mouth of a bottle into a bottle through heating and cooling the air inside the bottle so quickly as to create a slight vacuum.

This trick can be explained two different but complementary ways: density & pressure.
Density: The air inside the bottle is heated so that some of the air leaves, once the air cools, it takes up less room and a small vacuum is created.
Pressure: Cold air has a lower pressure than the warm air, causing creation of vacuum once the air cools.

Step 1:
Prepare materials: peel egg, roll up some paper, set matches/lighter up.

Step 2:
(This has to be done in a concerted manner, one step immediately after the other)
Light paper, stuff into bottle, and quickly place egg on top. Once the fire goes out, the egg should be sucked into the bottle.

Solar Balloon (~30-40 minutes)
OUTDOOR MODULE YAY!

Background: The solar balloon is a large black balloon that is filled with air and placed into direct sunlight. As the sunlight warms the balloon, the air inside expands and becomes less dense than the surrounding air causing the balloon to float/fly.

Procedure:
NOTE: The solar balloon is very finicky to get to work and sometimes it may not work, make sure to stress this to the students so that they are not disappointed. It needs to be sunny outside for the balloon to work. Perhaps have one mentor set the balloon up outside while everyone else does other modules in the mean time.

Step 1:
Take out balloon, it will look like a large trash bag. Do not open the balloon yet. Take a rubber band and tie off one end, tightly, as close to the end as possible

Step 2:
Fill balloon with air until about 90% full of air. It helps to open the balloon in the direction of a breeze and let the breeze fill the balloon. Tie off the open end with another rubber band and attach the cotton string. (Note: Do not use the fishing line that is included in the box, it is not very good for tying the balloon)

Step 3: (This is when you bring the students out to see balloon)
Place the balloon out in sunlight, hopefully, if it all works out, the balloon should start to hover/ float and maybe even fly. Feel free to let the kids play with it (I recommend no more than 2-3 at a time), but be careful as balloon is easy to pop/tear.