Go with the Flow: Solid ways to teach fluids

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Activities and images are courtesey of Paul Doherty at the Exporatorium Dozens more of his activities are online at http://www.exo.net/~pauld/site_map.html

Surface tension, Heal Thyself: *Surface-tension driven convection in milk*

http://www.exo.net/~pauld/activities/fluids/soapconvectionmilk.html
Covers: Forces, convection, solutions.

- Soap will "break" or reduce the surface tension of water and milk. The non-soap surface tension will then pull open and thus enlarge, the patch of soapy surface. Drops of dye placed on the surface will move along with the surface.
- We used dye mixed with clear dishwashing detergent, so the surfactant and dye were one and the same, causing a dramatic spreading effect as soon as the dye hit the milk
- You can also sprinkle pepper on the surface and watch it stream away from a dish-soap-dipped toothpick
- Try using high and low fat-content milk.
- Soap reduces the surface tension of the liquid. The stronger surface tension of the surrounding liquid then pulls the surface away from the weak, soapy region. The food coloring moves with the surface, streaming away from the soap.
- Try dropping alcohol into the dye-colored milk. Wow! (Alcohol also breaks up the surface tension)
- This is called the Marangoni Effect (see Wikipedia). It also explains “wine legs.”

Surface tension in space

http://www.sciencefriday.com/videos/watch/10177/

- Without gravity, surface tension can hold together much larger spherical droplets.

- Another great video of spherical water droplets in space here: http://www.youtube.com/watch?v=4Iax3wNqktA
- Drinking tea with chopsticks in space: http://www.youtube.com/watch?v=7obLT4s2-HA
- Download Youtube videos to your machine here: http://keepvid.com

Colored convection: *Falling colored cold*

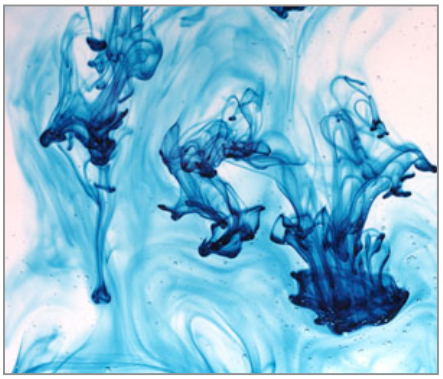
Covers: density, convection, heat

- Put a colored ice cube in water
- Watch the downward flow of water due to the temperature difference
- Convection is the transfer of mass or heat
- It was driven by surface tension in the milk activity – it's driven by heat differentials here
- We're used to seeing convection currents rise, not fall, due to heat instead of cold.
- You can also place a glass of colored hot water in a large tank of cold water to watch more complicated convection currents.
- In space, there's no buoyancy by displacement of fluid (air) to drive convection. Without convection, flames don't work (they smother in their waste gases, or, as in this example, the flame is fed by the expansion of gases away from the combustion, forming a spherical flame ball: http://www.youtube.com/watch?v=8IJ74IvpBlU

Breaking up is hard to do: *Bifurcation of water droplets*

http://www.exo.net/~pauld/activities/patterns/bifurcation.html

Covers: density, exponential growth (population growth)



- The food coloring is usually mixed into glycerin and is denser than water. The droplets fall under gravity. As they fall they break up into smaller droplets. (The droplets mix with water and so have no surface tension as they would if they fell through air.)
- This happens over and over again, it is a fractal process.
- Different colors of food coloring have different densities and so break up in different ways.
- I couldn't find old fashioned food coloring for this, and so used clear dishsoap (which contains glycerin) and mixed gel-style food coloring, plus a little water.
- The density can be modified by adding a little alcohol (which is less dense than water)
- We also put oil on top of the water and dropped food coloring on top. Watch the beautiful balls of color drop through the water.

- More fractals (with paint) at http://www.exo.net/~pauld/activities/patterns/fractalpaint.html

Bubble bottle: *Clean math*

http://www.exo.net/~pauld/activities/sweden/bubblebottle.html

Covers: Forces, surface tension

- Notice the pattern of bubbles in the bottle.
- In particular notice the pattern of bubble walls that touch the sides of the bottle.
- Notice how often three bubble walls come together at a point.
- Use the marker pen to draw several of the patterns of bubble walls.
- Notice that the angle between bubble films is near 120 degrees. (You can measure this with a protractor.)
- When bubble walls meet at 120 degree angles the surface area of the bubbles is minimized.
- Beehive walls also meet at an angle of 120 degrees, to save wax
- This is a great way to teach force equalization

Buoyancy and aluminum foil

http://www.exo.net/~pauld/activities/sweden/buoyancy.html

Covers: Buoyancy, density

- Crumple one piece of aluminum foil into a ball.
- Take another piece of aluminum foil and hold it under water, crumple it into a ball. Ask people what will happen when you release it, then release it. Notice that this ball sinks.
- Aluminum is denser than water, even when it is aluminum foil.
- When you crumple the foil in the air, air gets trapped in the ball making the ball less dense than water, so that it floats. When the ball is crumpled underwater no air is trapped so the aluminum remains denser than water.

Balloons and buoyancy: *PhET simulation*

http://phet.colorado.edu/simulations/sims.php?sim=Balloons_and_Buoyancy

- Simulations are a powerful way for your students to have hands-on experience in a way so they can explore the effects of different variables in isolation
- It directs their attention to the key parts of what you want them to notice about a real-world phenomenon