Problems With Fluids

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1 Pressure and Buoyancy

Pour some water (with density ρ) into a bowl of radius R up to a depth H. Push an upside-down cup (with mass m, radius r, and height h) into it.

1. How hard do you have to push down on the cup?
2. What is the air pressure inside the cup?
3. Are these two things related? Why?
4. Now place a rock in the bowl. What happens to the pressure? Why?
5. Do you have to push harder to hold the cup down? Why?
6. Now slowly lift the cup out of the water. What is the pressure when it is completely submerged? When it is partly submerged? When it is well above the surface?

2 Leaky pipe

Imagine a vertical tube of water with a hole h below the surface (with cross-sectional area A). When the hole is unplugged, a stream of water will come out. While you might think that the stream will be as wide as the hole, this turns out not to be the case. In this problem, we'll figure out how wide the stream will be. To make the problem easier, we will ignore both gravity's effect on the stream and the effect of the lowering water level.

1. What is the pressure at the depth of the hole?
2. What is the potential energy per mass due to pressure for water at this depth?
3. What is the velocity of the water once it escapes the hole? Hint: where does it get its kinetic energy?
4. What is the total force on the hole due to pressure?

5. What is the momentum of the water leaving the hole in a small interval of time t?

6. From the above two results, how big is the stream?

3 Challenge: Beading water on a spiderweb

(from Gnädig, Honyek, and Riley, "200 Puzzling Problems in Physics")

Outdoors at night, water vapour often condenses on cobwebs, on which we can find small, equally spaced, identical water drops. Find the minimum distance between drops, i.e. the smallest separation at which the drops do not regroup to form a solid coating of water. Hint: Assuming the surface energy per area for water is w, compare the surface energy of a long cylinder of water (a cobweb evenly covered in water) with that of the same water collected into spherical drops.