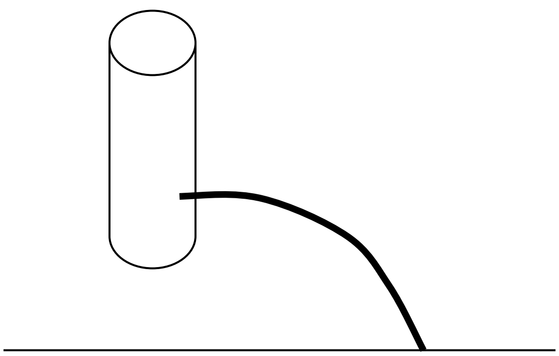
Name: ____________________

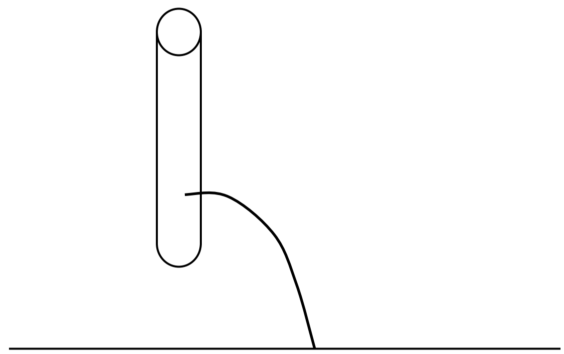
Date: _____________ Period: ___________

Fluids Worksheet 2
Gravitational and Kinetic Energy Density

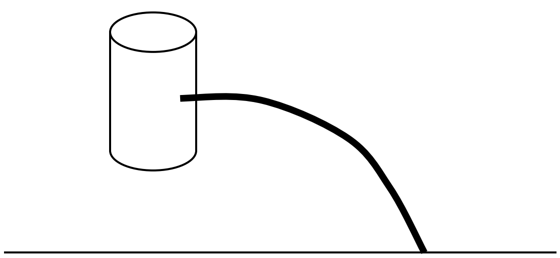
1. In the diagrams below, several tubes are filled to overflowing with water, while fluid escapes through a hole near the bottom. The thickness of the line indicates the diameter of the both the hole and the stream escaping. The first diagram represents an actual experimental observation. Compared to this first diagram, what, if anything, is wrong with diagrams A through E?



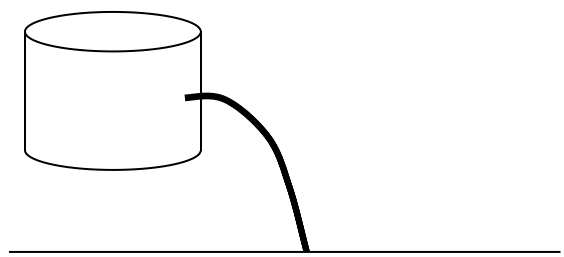
First diagram
actual experimental observation



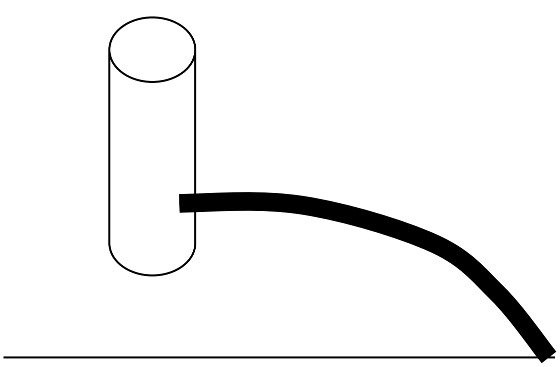
A. What, if anything, is wrong?



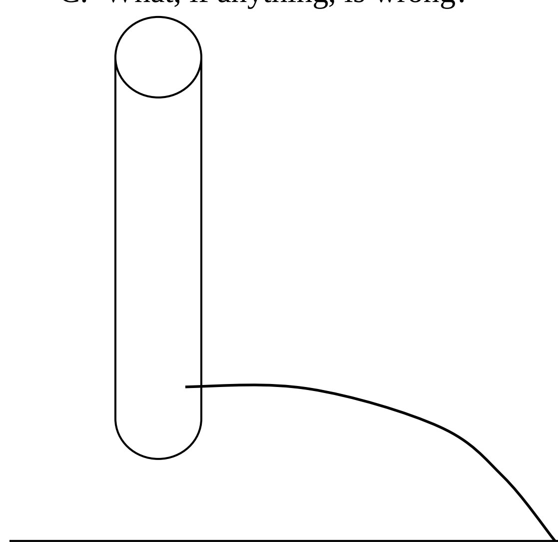
B. What, if anything, is wrong?



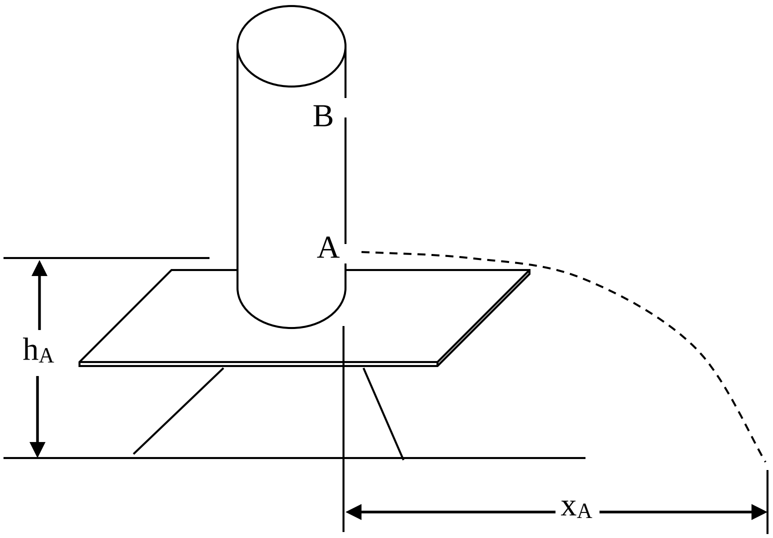
C. What, if anything, is wrong?



D. What, if anything, is wrong?

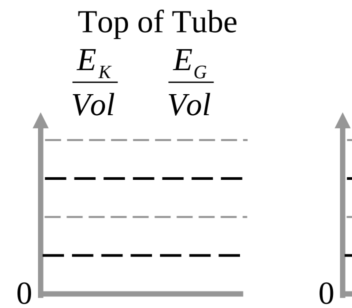


E. What, if anything, is wrong?



2. (a) The tube at left is filled with water until it overflows at the top. When hole A is unplugged, water lands at x_A. When hole A is plugged and hole B then is unplugged, where will it land? Will x_B be *greater than*, *less than*, or *the same as* x_A?
(b) Explain your reasoning.

3. In one specific example of a situation like problem 2, the tube has a diameter of 7.5cm, the height h_A is 1.0m, the distance between holes A and B is 0.50m, and the distance from hole B to the top of the tube is 1.0m. Each hole has a diameter of 6mm. (a) Draw a quantitatively correct energy density bar graph for the fluid at the top of the tube, as it just exits hole B, and as it just exits hole A. Ignore any dissipation of energy during the flow.



(b) Determine the velocity with which the fluid exits each hole.

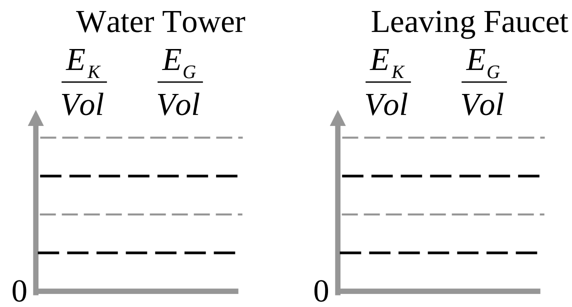
(c) For each hole, determine the horizontal distance from the tube to where the fluid hits the ground.

(d) i. At what rate does fluid flow through each hole?

ii. At what rate does *energy* leave the tube through each hole?

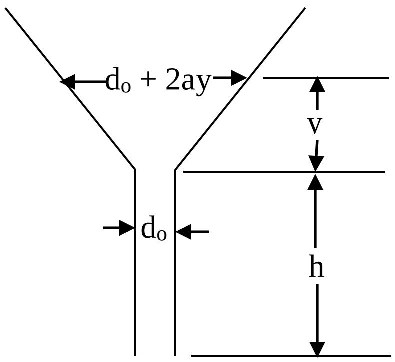
iii. At what rate must both fluid and energy be added at the top of the tube to maintain the steady state? Verify that this is, in fact, the rate at which energy is added at the top.

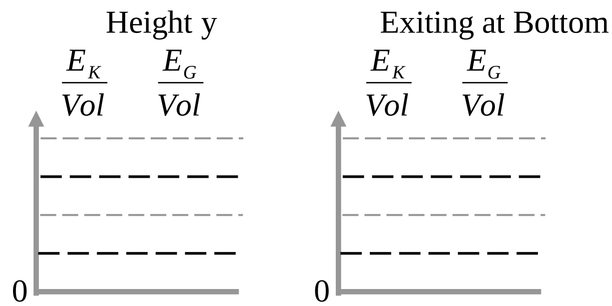
4. Municipal utilities use water towers to pressurize their water. (a) Draw energy density bar graphs for the water in the top of the tower and the water flowing out of your household faucet, which has a diameter of 5/8 inches and a maximum flow rate of 2.0gallons per minute.



(b) How high should the water tower be to ensure that your faucet will operate properly? Ignore any dissipation of energy in the pipes.

5. The kitchen funnel shown below has a width d_o at its narrowest part and sides of slope a, so that the width of the funnel at a height y above the constriction is given by the formula $d = d_o + 2ay$. At the bottom, the funnel narrows into a tube of width d_o and length h. (a) Suppose that water fills the funnel up to level y and is draining with velocity v_y (at height y) and velocity v (as it exits at the bottom.) Draw energy density bar graphs for the fluid at height y and as it exits, expressing all energy densities in terms of the variables d_o, a, y, v,v_y, the density ρ, and universal constants. Ignore dissipation.



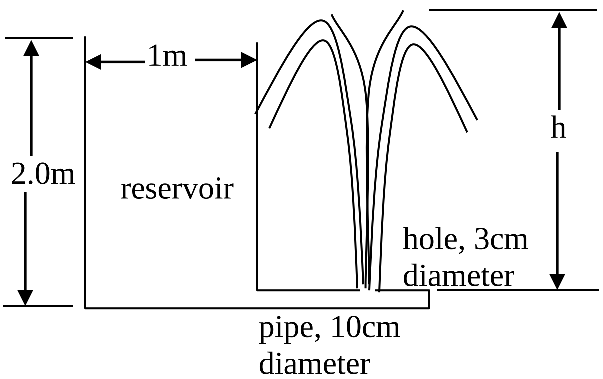


(b) Use the energy density bar graphs to write an equation involving these variables.

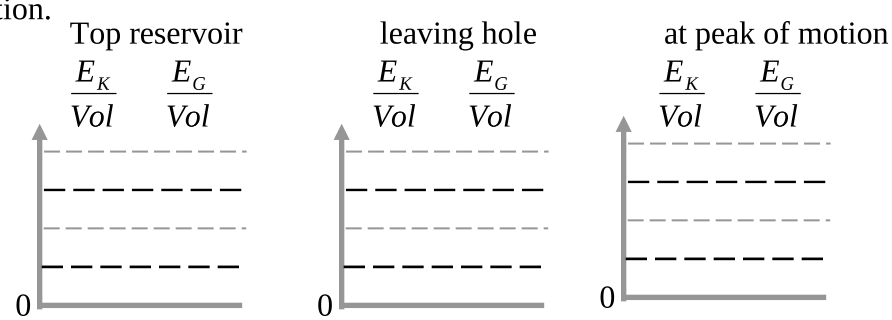
(c) Use the continuity equation to write another equation involving these variables.

(d) Eliminate v_y from these equations to derive an expression for the velocity with which fluid exits the funnel in terms of the other variables.

(e) EXTRA CREDIT: Write a computer program to determine how long it will take to empty the funnel and test your prediction with an experiment. If you are interested, I will be glad to help you set this up.



6. You are part of a student group submitting an entry in a competition to design a new fountain for the quad. In addition to the artistic design, you are also required to explain the technical details of how it is set up. Your group has produced this sketch of a possible design, and would like you to do the technical part because you've studied some physics. After the water spews into the air and falls back to the ground, it is contained in a concrete pool and pumped back into the reservoir, so that the reservoir is continually filled to the top. (a) Draw a set of quantitatively correct energy density bar graphs for the fluid at the top of the reservoir, leaving the hole, and at the peak of the fountain. Ignore dissipation.



(b) With what velocity does the fluid leave the base of the fountain?

(c) How high does the water of the fountain go? Explain.

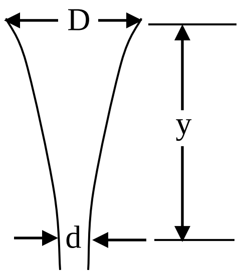
(d) In order to increase the height of the fountain, members of your design team make the following suggestions. In each case, explain to the team whether or not the suggestion is a good idea.

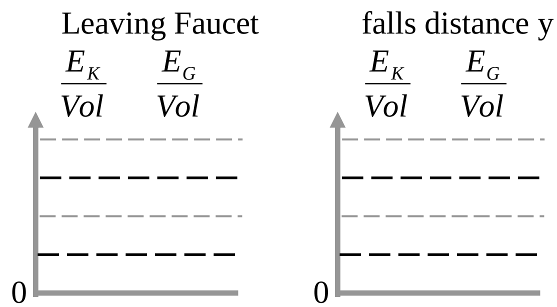
i. Increase the diameter of the reservoir so there is a larger weight of fluid pushing out.

ii. Enlarge the diameter of the pipe so the flow is not so constricted.

iii. Make the exit hole larger, so that the fluid can escape faster.

7. The stream of water from a faucet decreases in diameter as it falls. If the velocity and diameter of the flow are small, this decrease in diameter is primarily due to surface tension. For larger, faster flows, the diameter decreases primarily due to another effect.
(a) Draw an energy density bar graph for a large diameter, quickly flowing fluid as it just leaves the faucet and after it has fallen a distance y. Express your answers in terms of the water speed, v_o, when it leaves the faucet, the faucet diameter, D, y, the velocity v_y after falling the distance y, and universal constants. You may neglect all effects of surface tension and dissipation.





(b) Derive an equation for the diameter of the stream as a function of the distance y below the faucet in terms of v_o, D, and y.

(c) According to your equation, what happens to the diameter of the stream as y becomes larger and larger? Do you think this is what happens in real life? Explain.

(d) EXTRA CREDIT: Devise a way to test this prediction experimentally. If you are interested, I will be glad to help you set this up.