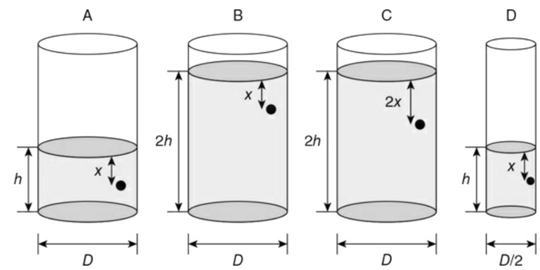
AP PHYSICS 2: FLUID MECHANICS

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and place the letter of your choice in the corresponding box on the student answer sheet.

Note: To simplify calculations, you may use $g = 10\,\mathrm{m/s^2}$ in all problems.

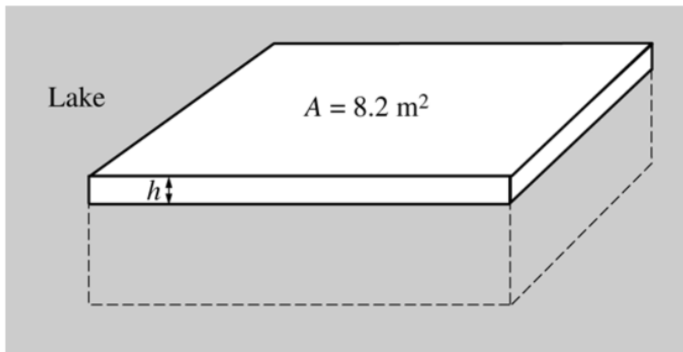
1. The figure shows four cylinders of various diameters filled to different heights with water. A hole in the side of each cylinder is plugged by a cork. All cylinders are open at the top. The corks are removed. Which of the following is the correct ranking of the velocity of the water (v) as it exits each cylinder?



(A) $v_A > v_D > v_C > v_B$
(B) $v_A = v_D > v_C > v_B$
(C) $v_B > v_C > v_A = v_D$
(D) $v_C > v_A = v_B = v_D$

AP PHYSICS 2: Fluid Mechanics
SECTION II
5 Questions

Directions: Answer all questions. The parts within a question may not have equal weight. All final numerical answers should include appropriate units. Credit depends on the quality of your solutions and explanations, so you should show your work. Credit also depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should clearly indicate which part of a question your work is for.



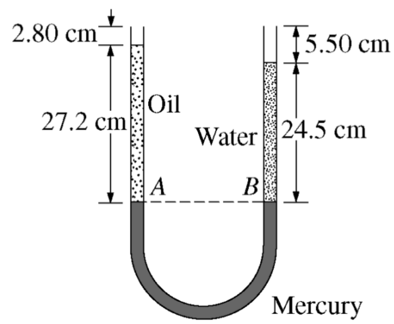
Note: Figure not drawn to scale.

1. A large rectangular raft (density $650\,\text{kg/m}^3$) is floating on a lake. The surface area of the top of the raft is $8.2\,\text{m}^2$ and its volume is $1.80\,\text{m}^3$. The density of the lake water is $1000\,\text{kg/m}^3$.

   (a) Calculate the height h of the portion of the raft that is above the surrounding water.

   (b) Calculate the magnitude of the buoyant force on the raft and state its direction.

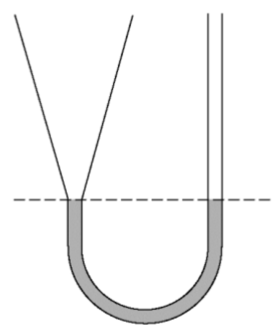
   (c) If the average mass of a person is 75 kg, calculate the maximum number of people that can be on the raft without the top of the raft sinking below the surface of the water. (Assume that the people are evenly distributed on the raft.)



2. A glass U-tube with a uniform diameter of 0.850 cm is used to determine the density of an oil. As shown in the figure above, a 24.5 cm column of water balances a 27.2 cm column of the oil so that interfaces *A* and *B* of the mercury with the other liquids are at the same height. The density of water is 1.00×10^3 kg/m^3.

   (a) Calculate the density of the oil.

   (b) Calculate the absolute pressure at *B*, the interface between the water and the mercury.



A new tube, identical to the U-tube except for a cone shape on the left, as shown above, is filled with the same volume of mercury that was in the U-tube. The mercury is at the same height on both sides of the new tube as it was in the U-tube, as shown by the dashed line. The same volumes of oil and water that were in the U-tube are now poured into the new tube, on the left and right respectively.

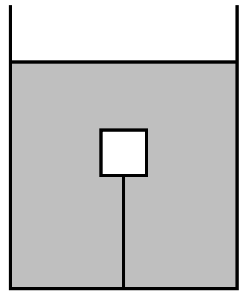
   (c) Indicate the new position of *B* relative to *A*.

   ____ Above *A* ____ Below *A* ____ At the same height as *A*

   Justify your answer.

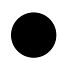
   (d) A small piece of wood with density less than that of the oil is placed so that it floats in the left side of the tube. Indicate whether the pressure at the bottom of the tube increases, decreases, or remains the same.

   ____ Increases ____ Decreases ____ Remains the same



3. A cube of mass m and side length L is completely submerged in a tank of water and is attached to the bottom of the tank by a string, as shown in the figure above. The tension in the string is 0.25 times the weight of the cube. The density of water is $1000\,\mathrm{kg/m^3}$.

   (a) On the dot below that represents the cube, draw and label the forces (not components) that act on the cube while it is attached to the string. Each force must be represented by a distinct arrow starting on, and pointing away from, the dot.



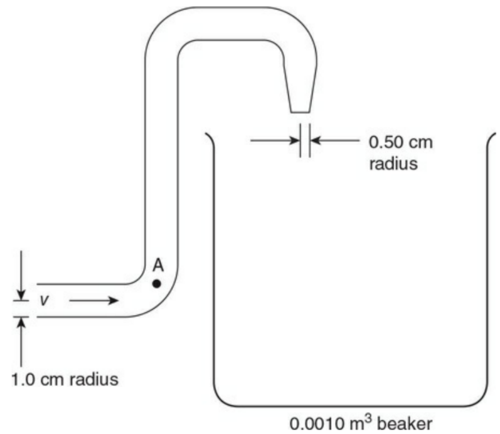
   (b) Calculate the density of the cube.

   (c) The string is now cut. Calculate the magnitude of the acceleration of the cube immediately after the string is cut. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. Do NOT add anything to the figure in part (a).

   (d) Indicate whether the magnitude of the buoyant force on the cube increases, decreases, or remains the same while the cube is rising, but before it reaches the surface.

   ____ Increases ____ Decreases ____ Remains the same

   Justify your answer.



4. A 1.0 cm radius hose with a 0.50 cm radius exit nozzle is being used to fill a 1000 ml beaker with oil (1000 ml=0.0010 m^3). The velocity of the oil in the hose is v = 0.40 m/s as shown in the figure. The density of the oil is 960 kg/m^3, and the atmospheric pressure is 1.01×10^5 Pa.

   (a) The nozzle attached to the end of the hose has a smaller radius than the hose. If the nozzle is removed from the hose, will the beaker be filled faster? Justify your answer with conservation laws.

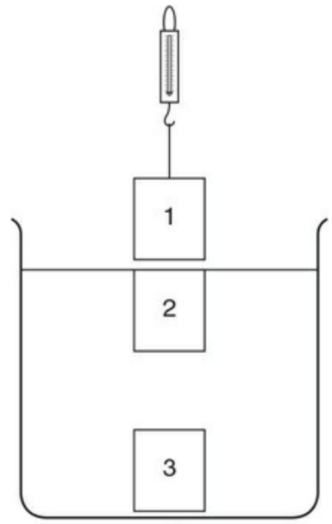
   (b) Calculate the exit velocity of the oil from the nozzle.

   (c) How long will it take to fill the beaker?

   (d) Point A is shown in the figure. How does the pressure in the fluid at point A compare to the pressure in the fluid at the exit nozzle? Justify your claim.

   (e) The hose is now used to fill a 200 ml graduated cylinder with oil to the same height as the height of the oil in the 1000 ml beaker. Compare the net force from the oil on the bottom of the 200 ml cylinder and the 1000 ml. Explain your answer.

(f) A cube of lead with a side dimension of 5.0 cm is slowly lowered into the beaker of oil by a thin string attached to a spring scale at a constant rate, as shown in the figure. The density of lead is 11,300 kg/m^3.



0.0010 m^3 beaker

i. What will be the spring scale reading in newtons when the lead has been submerged to location 2?

ii. Does the spring scale reading increase, decrease, or stay the same when the cube is lowered from location 2 to location 3? Justify your answer by referencing the pressure of the fluid on the lead cube.

iii. The lead cube is lowered from above the oil's surface (location 1) to a spot just below the surface (location 2) until the cube is just above the bottom of the beaker (location 3). Describe any changes in pressure on the bottom of the beaker during this process. Explain your answer.