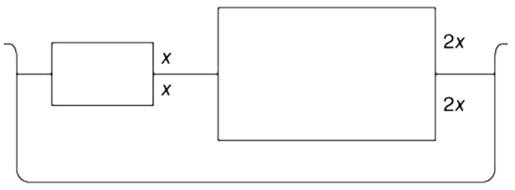
Student #: ____________________ Student Name: ________________________

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.

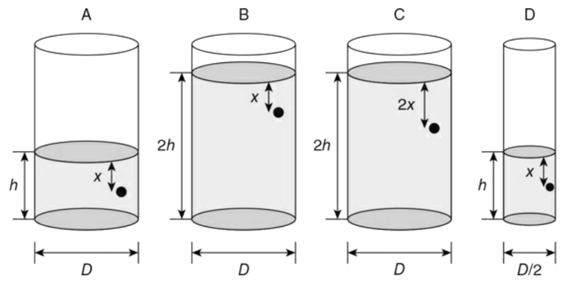
Note: To simplify calculations, you may use $g = 10\,\text{m/s}^2$ in all problems.

1. Two blocks of different sizes and masses float in a tray of water. Each block is half submerged, as shown in the figure. Water has a density of $1000\,\text{kg/m}^3$. What can be concluded about the densities of the two blocks?



(A) The two blocks have different densities, both of which are less than $1000\,\text{kg/m}^3$.
(B) The two blocks have the same density of $500\,\text{kg/m}^3$.
(C) The two blocks have the same density, but the density cannot be determined with the information given.
(D) The larger block has a greater density than the smaller block, but the densities of the blocks cannot be determined with the information given.

2. 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?



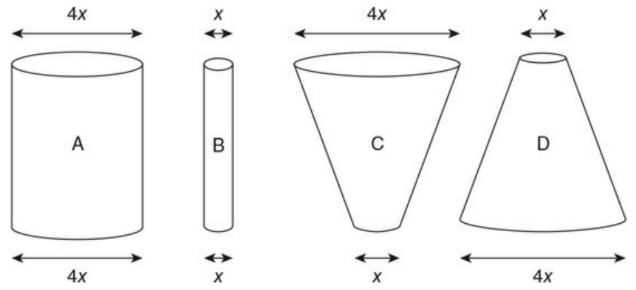
(A) $v_A > v_D > v_C > v_B$
(B) $v_A = v_D > v_C > v_B$
(C) $v_B > v_C > v_A = v_D$
(D) $v_C > v_A = v_B = v_D$

3. A 1 cm diameter pipe leads to a showerhead with twenty 1 mm diameter exit holes. The velocity of the water in the pipe is v. What is the velocity of the water exiting the holes?

(A) $0.05v$
(B) $0.5v$
(C) $5v$
(D) $100v$

Questions 4 and 5

Four differently shaped sealed containers are completely filled with alcohol, as shown below. Containers A and B are cylindrical. Containers C and D are truncated conical shapes. The top and bottom diameters of the containers are shown.



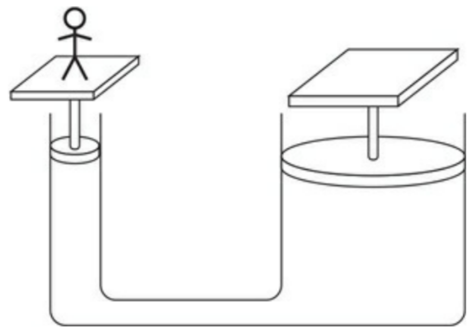
4. Which of the following is the correct ranking of the pressure (P) at the bottom of the containers?

(A) $P_A = P_B = P_C = P_D$
(B) $P_A = P_D > P_C = P_B$
(C) $P_A > P_D > P_C > P_B$
(D) $P_D > P_A > P_C > P_B$

5. The force on the bottom of container A due to the fluid inside the container is F. What is the force on the bottom of container B due to the fluid inside?

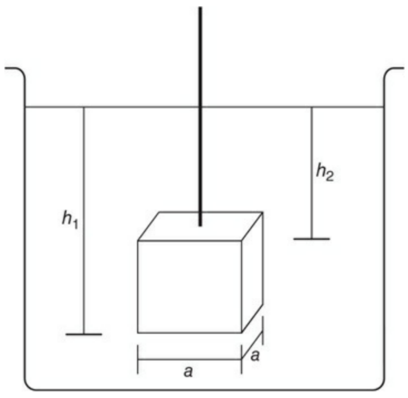
(A) F
(B) $F/4$
(C) $F/8$
(D) $F/16$

6. Two cylinders filled with a fluid are connected by a pipe so that fluid can pass between the cylinders, as shown in the figure. The cylinder on the right has 4 times the diameter of the cylinder on the left. Both cylinders are fitted with a movable piston and a platform on top. A person stands on the left platform. Which of the following lists the correct number of people that need to stand on the right platform so neither platform moves. Assume that the platform and piston have negligible mass and that all the people have the same mass.



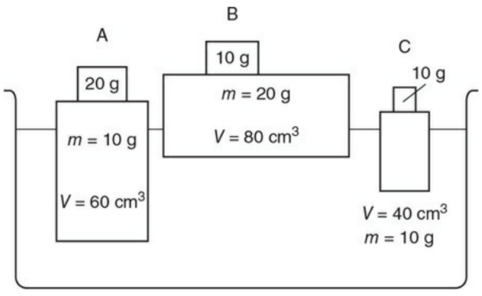
(A) 16 people
(B) 4 people
(C) 1 person
(D) It is impossible to balance the system because you need $1/16$ of a person on the right side.

7. A mass m is suspended in a fluid of density ρ by a string, as shown in the figure below. The tension in the string is T. Which of the following is an appropriate equation for the buoyancy force? Select two answers.



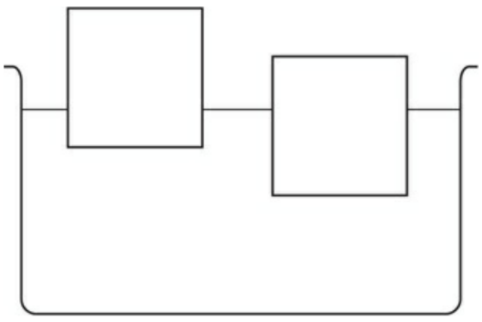
(A) $F_b = mg$
(B) $F_b = mg - T$
(C) $F_c = a_2\rho g h_1$
(D) $F_d = a\rho g(h_1 - h_2)$

8. Three wooden blocks of different masses and sizes float in a container of water, as shown in the figure. Each of the masses has a weight on top. Which of the following correctly ranks the buoyancy force on the wooden blocks?



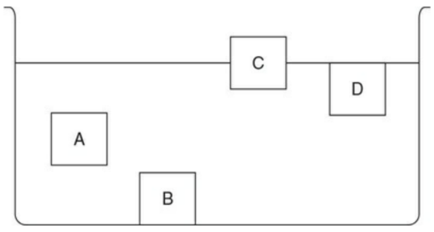
(A) $A > B = C$
(B) $A = B > C$
(C) $B > A = C$
(D) $B > A > C$

9. Two blocks of the same dimensions are floating in a container of water, as shown in the figure. Which of the following is a correct statement about the two blocks?



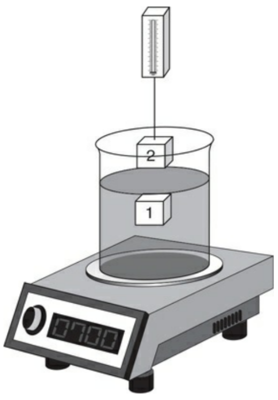
(A) The net force on both blocks is the same.
(B) The buoyancy force exerted on both blocks is the same.
(C) The density of both blocks is the same.
(D) The pressure exerted on the bottom of each block is the same.

10. The figure shows four cubes of the same volume at rest in a container of water. Cube C is partially submerged. Cubes A, B, and D are fully submerged, with B resting on the bottom of the container. Which of the following correctly ranks the densities (ρ) of the cubes? Assume the water to be incompressible.



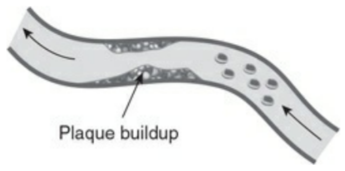
(A) $\rho_C > \rho_D > \rho_A > \rho_B$
(B) $\rho_B > \rho_A > \rho_D > \rho_C$
(C) $\rho_B > \rho_A = \rho_D > \rho_C$
(D) $\rho_B > \rho_A = \rho_D = \rho_C$

11. A beaker of water sits on a balance. A metal block with a mass of 70 g is held suspended in the water by a spring scale in position 1, as shown. In this position, the reading on the balance is 1260 g, and the spring scale reads 120 g. When the block is lifted from the water to position 2, what are the readings on the balance and spring scale?



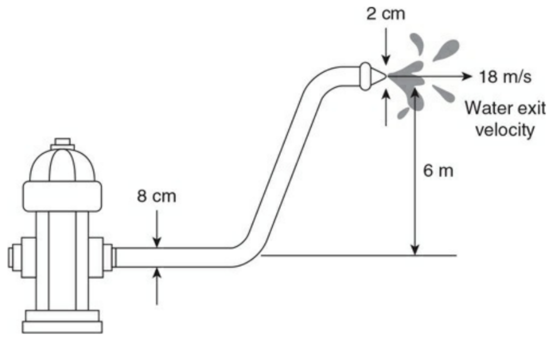
	Balance reading	**Spring scale reading**
(A)	1190 g	120 g
(B)	1190 g	190 g
(C)	1260 g	120 g
(D)	1330 g	120 g

12. Blood cells pass through an artery that has a buildup of plaque along both walls, as shown in the figure. Which of the following correctly describes the behavior of the blood cells as they move from the right side of the figure through the area of plaque? Assume the blood cells can change volume.



(A) The blood cells increase in speed and expand in volume.
(B) The blood cells increase in speed and decrease in volume.
(C) The blood cells decrease in speed and expand in volume.
(D) The blood cells decrease in speed and decrease in volume.

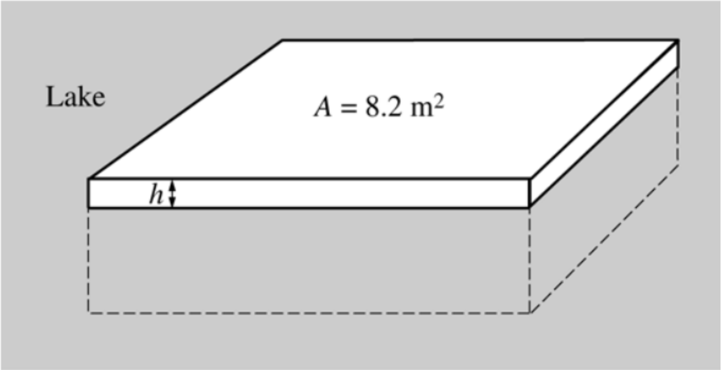
13. Firefighters use a hose with a 2 cm exit nozzle connected to a hydrant with an 8 cm diameter opening to attack a fire on the second floor of a building 6 m above the hydrant, as shown in the figure. What pressure must be supplied at the hydrant to produce an exit velocity of 15 m/s? (The density of water is 1000 kg/m^3, and the exit pressure is 1×10^5 Pa.)



(A) 1.7×10^5 Pa
(B) 2.0×10^5 Pa
(C) 2.6×10^5 Pa
(D) 3.2×10^5 Pa

AP PHYSICS 2: FIUID MECHANICS
SECTION II
4 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.



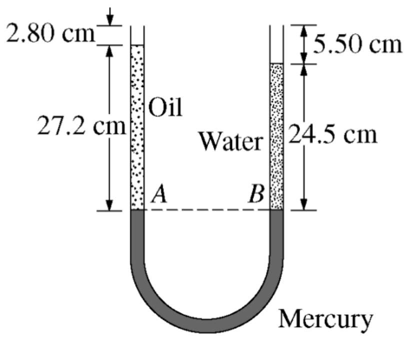
Note: Figure not drawn to scale.

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

   (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.

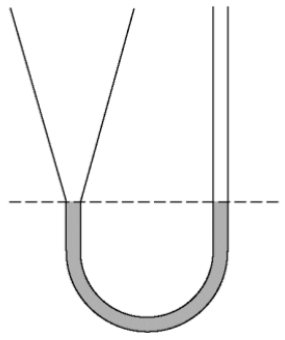
   (c) If the average mass of a person is $75\,\mathrm{kg}$, calculate the maximum number of people that can be on the raft without the top of the raft sinking below the surface of the water. (Assume that the people are evenly distributed on the raft.)



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 $1.00 \times 10^3\ \mathrm{kg/m^3}$.

   (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.

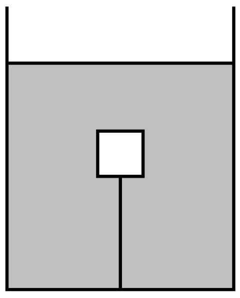
   (c) Indicate the new position of *B* relative to *A*.

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

   Justify your answer.

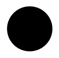
   (d) A small piece of wood with density less than that of the oil is placed so that it floats in the left side of the tube. Indicate whether the pressure at the bottom of the tube increases, decreases, or remains the same.

   ____ 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.

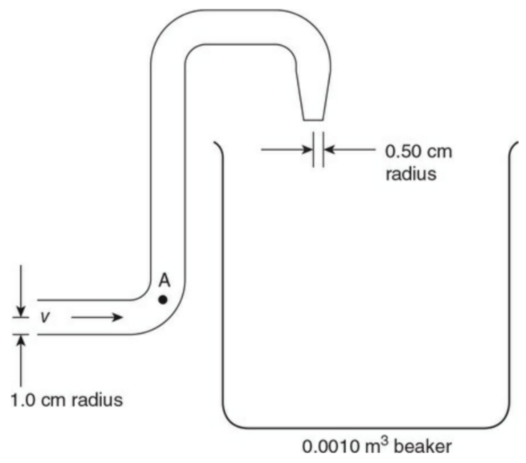
   (b) Calculate the density of the cube.

   (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 $v = 0.40\,\mathrm{m/s}$ as shown in the figure. The density of the oil is 960 $\mathrm{kg/m^3}$, 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.

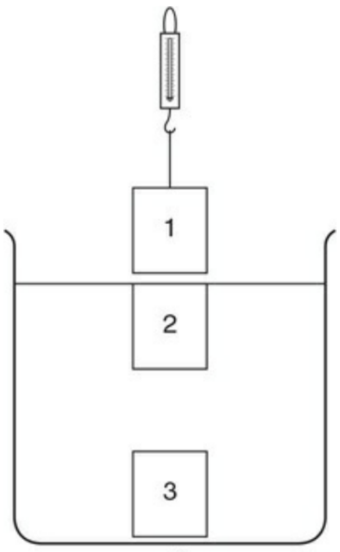
   (b) Calculate the exit velocity of the oil from the nozzle.

   (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.

5. 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.



(a) What will be the spring scale reading in newtons when the lead has been submerged to location 2?

(b) 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.

(c) 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.