FLUIDS HANDOUT

1. Background Information

Pressure in a fluid:

$$P = P_0 + \rho g h$$

where P_0 is the pressure at the surface of the fluid, ρ is the density, and h is the height from the surface.

Archimedes Principle:

$$F_b = \rho V g$$

where F_b is the buoyant force, ρ is the density, V is the volume displaced, and g is the acceleration due to gravity.

Continuity Equation:

$$Av = \text{const.}$$

where A is the cross sectional area and v is the velocity. This is basically conservation of mass.

Bernoulli's Equation:

$$P + \rho g h + \frac{1}{2}\rho v^2 = \text{const.}$$

where P is the pressure, ρ is the density, h is the height, and v is the velocity. This is basically conservation of energy. One special case of this is when there is a hole in a cylinder full of water and you want to know how fast water exits the hole. Torricelli's Law:

$$v = \sqrt{2gh}$$

where h is the height of the hole from the surface. Notice that this is the same equation for the velocity of a ball dropped from a height of h.

2. Problems

(1) A 3.0 cm thick layer of oil with density $\rho_o = 800\text{kg/m}^3$ is floating above water that has density $\rho_w = 1000\text{kg/m}^3$. A solid cylinder is floating so that 1/3 is in the water, 1/3 is in the oil, and 1/3 is in the air. Additional oil is added until the cylinder is floating only in oil. What fraction of the cylinder is in the oil?

(2) A block floats partially submerged in a container of liquid. When the entire container is accelerated upward, which of the following happens? Assume that both the liquid and the block are incompressible.
   (A) The block descends down lower into the liquid.
   (B) The block ascends up higher in the liquid.
   (C) The block does not ascend nor descend in the liquid.
   (D) The answer depends on the direction of motion of the container.
   (E) The answer depends on the rate of change of the acceleration

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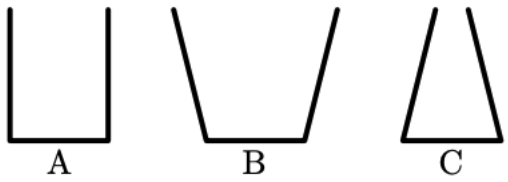
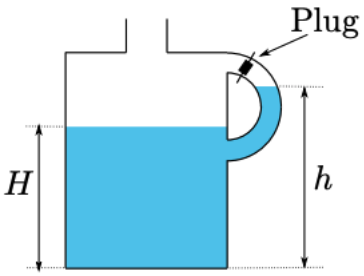
(3) Flasks A, B, and C each have a circular base with a radius of 2 cm. An equal volume of water is poured into each flask, and none overflow. Rank the force of water F on the base of the flask from greatest to least.



(A) $F_A > F_B > F_C$
(B) $F_A > F_C > F_B$
(C) $F_B > F_C > F_A$
(D) $F_C > F_A > F_B$
(E) $F_A = F_B = F_C$

(4) The handle of a gallon of milk is plugged by a manufacturing defect. After removing the cap and pouring out some milk, the level of milk in the main part of the jug is lower than in the handle, as shown in the figure. Which statement is true of the gauge pressure P of the milk at the bottom of the jug? ρ is the density of the milk.



(A) $P = \rho g h$
(B) $P = \rho g H$
(C) $\rho g H < P < \rho g h$
(D) $P > \rho g h$
(E) $P < \rho g H$

(5) A balloon filled with air submerged in water at a depth h experiences a buoyant force B_0. The balloon is moved to a depth of $2h$, where it experiences a buoyant force B. Assuming the water is incompressible and the balloon and air are compressible, the buoyant force B satisfies
(A) $B \geq 2B_0$
(B) $B_0 < B < 2B_0$
(C) $B = B_0$
(D) $B < B_0$
(E) it depends on the compressibility of the balloon and air

(6) A car is turning left along a circular track of radius r at a constant speed v. A cylindrical beaker is placed veritcally inside the car. The beaker has a small hole on its right side. If the water's highest point in the beaker is a height of h above the hole, at what instantaneous speed does water escape the hole, from a passenger's perspective?