Phy 131-Assignment 14

A. Equation of continuity: $v_L A_L = v_H A_H$ (L = lower, H = higher)

$(75\ cm^2)(.4\ m/s) = (10\ cm^2)v_H$

v_H = $\underline{3.00\ m/s}$ ans.

$P_L + ½\rho\, v_L^2 + \rho\, gh_L = P_H + ½\rho\, v_H^2 + \rho\, gh_H$ (Bernoulli's equation)

3.00×10^5 Pa + ½(1000)(.4)² + 0 = P_H + ½(1000)(3)² + (1000)(9.8)(25 m)

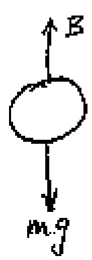
$3.00 \times 10^5 + 80 = P_H + 4500 + 2.45 \times 10^5$

$3.00 \times 10^5 + 80 - 4500 - 2.45 \times 10^5 = P_H$

P_H = $\underline{5.06 \times 10^4\ Pa}$ ans.

B. 1. The level falls. While in the boat, the anchor is supported by buoyancy, and so it displaces its weight of water, by making the boat sit low. When you throw the anchor out, the boat pops up, lowering the water level. Submerged in the lake, the anchor still displaces some water, but just its volume of water. Its weight of water takes up more space than its volume of water because the anchor is denser than water.

2.



B = weight of displaced air = $(\rho_{air} V_{displaced})g$

$= (1.29\ kg/m^3)(.0058\ m^3)(9.8\ m/s^2)$

$= .07332$ N

$mg = (.00315)(9.8) = .03087$ N

$$\Sigma F_y = ma$$

$$.07332 - .03087 = (.00315\ kg)\ a$$

$$.04245 = .00315\ a$$

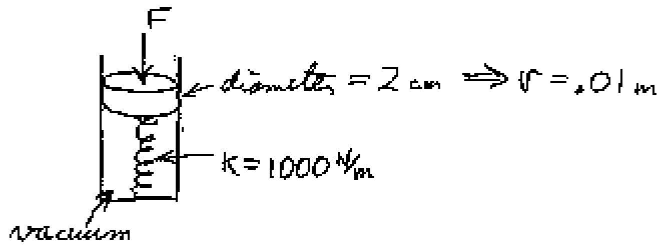
$$a = \frac{.04245}{.00315} = \boxed{13.5\ m/s^2}$$

C. Hooke's law: $F = kx$

$F = (1000\ \text{N/m})(.005\ \text{m})$

Spring compresses by .5 cm

$F = 5.00\ \text{N}$



The pressure which will exert this much force:

$$P = \frac{F}{A} = \frac{5\ \text{N}}{.000314} = 15\ 915\ \text{Pa}$$

$$A = \pi r^2 = \pi(.01\ \text{m})^2 = .000314\ \text{m}^2$$

Depth corresponding to this pressure:

$$\Delta P = -\rho g \Delta h \Rightarrow -\Delta h = \frac{\Delta P}{\rho g} = \frac{15\ 915}{(1000\ \frac{\text{kg}}{\text{m}^2})(9.8)} = \boxed{1.62\ \text{m}}$$

"Depth" would be the negative of "height."

D. 1. If the dimensions are the same, the buoyant force is the <u>same</u>. It depends on the weight of the displaced water, not the weight of the object itself.

2.

Pascal's Principle:

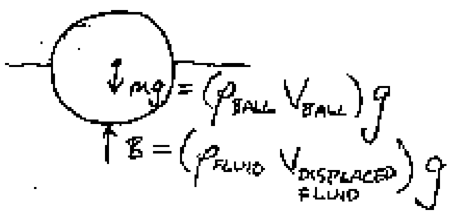
$$\Delta P_1 = \Delta P_2$$

$$\frac{\Delta F_1}{A_1} = \frac{\Delta F_2}{A_2} \rightarrow \Delta F_1 = \frac{A_1}{A_2}\Delta F_2$$

$$= \frac{\pi\,(1\ \text{cm})^2}{\pi\,(8\ \text{cm})^2}\,(15{,}000\ \text{N})$$

$$15000/64 = \boxed{234\ \text{N}}$$

E.



In water, (ρ of water)

$$\Sigma F_y = 0 \Rightarrow \rho_B V_B g = (1000\ \tfrac{kg}{m^3})(.5V_B)g$$

$$\rho_B = \boxed{500\ \tfrac{kg}{m^3}}$$

In glycerin, $\Sigma F_y = 0 \Rightarrow$

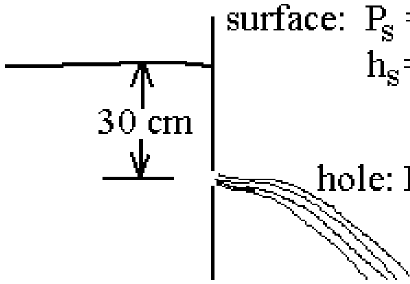
$$(500\ kg/m^3)(V_B)(g) = \rho_{gly}(.4V_B)g$$

$$500 = .4\rho_g$$

$$\rho_g = \frac{500}{.4} = \boxed{1250\ \tfrac{kg}{m^3}}$$

F.

A) This can be done with Torricelli's Law, but personally, I prefer to work from basic principles instead of keeping track of a lot of specialized equations.



surface: $P_s = 1$ atm, $v_s = 0$ (water level drops very slowly), $h_s = .30$ m

hole: $P_h = 1$ atm, $v_h = ?$, $h_h = 0$

$$P_s + \frac{1}{2}\rho v_s^2 + \rho g h_s = P_h + \frac{1}{2}\rho v_h^2 + \rho g h_h$$

$$\cancel{1\ \text{atm}} + \frac{1}{2}\rho(0)^2 + (1000)(9.8)(.3) = \cancel{1\ \text{atm}} + \frac{1}{2}(1000)v_h^2 + \rho g(0)$$

$$(\cancel{1000})(9.8)(.3) = \frac{1}{2}(\cancel{1000})v_h^2$$

$$\sqrt{(2)(9.8)(.3)} = v_h$$

ans: 2.42 m/s

B) The water is launched with $\vec{v}_i = 2.42\hat{i} + 0\hat{j}$ m/s

Time to fall 45 cm: $\Delta y = v_{iy}t + \frac{1}{2}a_y t^2$

$$.45\ \text{m} = 0 + \frac{1}{2}(9.8)\,t^2 \quad \text{(down = positive)}$$

$$\frac{(2)(.45)}{9.8} = t^2$$

$$t = .303\ \text{s}$$

Horizontal distance traveled in .303 s:

$$\Delta x = v_x t = (2.42\ \text{m/s})(.303\ \text{s}) = \underline{.733\ \text{m}}$$