Name: Key (Per 4/5) Period:

Fluid Statics Problem Packet- Buoyancy, Pressure & Floating Things

App Wt in H_2O = 36 N
App Wt in Liq = 41 N

1. A piece of metal weighs 50.0 N in air, 36.0 N in water and 41.0 N in an unknown liquid. The density of water (D_{water}) is 1000 kg/m^3. Find the densities of the metal and the unknown liquid.

$\frac{W}{F_B} = \frac{D_{object}}{D_{Fluid}}$

$F_{B\text{-}H_2O} = 50 - 36 = 14\text{ N}$

$F_{B\text{-}Liq} = 50 - 41 = 9\text{ N}$

Water

$\frac{50\text{N}}{14\text{N}} = \frac{D_{Metal}}{1000\text{ kg/m}^3}$

$D_{metal} = 3{,}571.4\ \text{kg/m}^3$

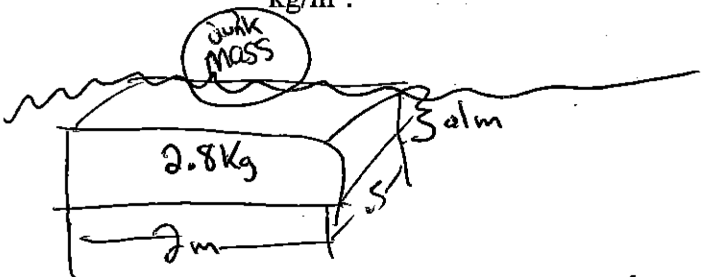
Unknown Liq

$\frac{50\text{N}}{9\text{N}} = \frac{3{,}571.4\ \text{kg/m}^3}{D_{Liq}}$

$D_{Liq} = 642.8\ \text{kg/m}^3$

2. A 2.8 kg rectangular air mattress is 2.00 m long, 0.500 m wide, and 0.100 m thick. What mass can it support in water before sinking? The density of fresh water (D) is 1000 kg/m^3.

$D = \frac{M}{V}$ $\quad$ $M = D \cdot V$



$mass_{stuff} = M_{fluid}$

$mass_{mattress} + mass_{junk} = M_{water}$

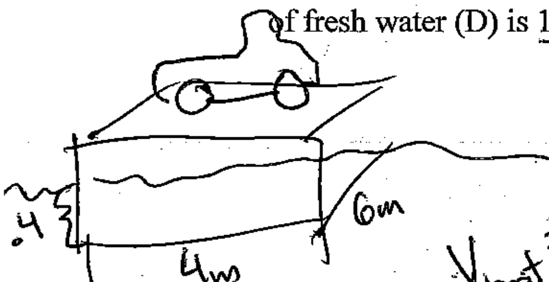
$2.8\text{ kg} + mass_{junk} = D_{water} \cdot V_{water}$

$V_{water} = V_{mattress} = 2 \times .5 \times .1 =$ $V_w = .1\text{ m}^3$

$2.8 + x = (1000\ \text{kg/m}^3)(.1\ \text{m}^3)$

$2.8 + x = 100$ $\quad$ $x = 97.2\text{ kg}$

3. A ferry boat is 4.0 m wide and 6.0 m long. When a truck pulls onto it, the boat sinks 0.400 m in the water. What is the combined mass of the truck and the ferry? The density of fresh water (D) is 1000 kg/m^3.



$mass_{stuff} = mass_{fluid}$

$V_{boat} = V_{water} = 4 \times 6 \times .4 = 9.6\text{ m}^3$

$mass_{truck/boat} = M_{water} = D_w \cdot V_w$

$9{,}600\text{ kg} = (1000\ \text{kg/m}^3)(9.6\ \text{m}^3)$

4. A 650 kg weather balloon is designed to lift a 4600 kg package. What volume should the balloon have after being inflated with helium (under standard conditions) to lift the total load? The density of air (D) is 1.29 kg/m^3. The density of helium (D) is 0.179 kg/m^3. (Hint: the "fluid" being displaced by the helium balloon is the air.)

$V_{He} = V_{Air} = V$

$M_{stuff} = M_{fluid}$

$M_{balloon} + M_{package} + M_{Helium} = M_{air}$

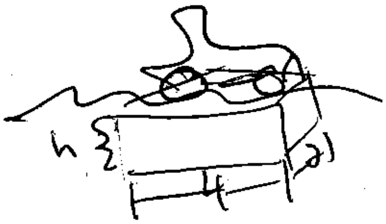
$650\text{ kg} + 4600\text{ kg} + D_{He} V_{He} = D_{Air} \cdot V_{Air}$

$650 + 4600 + .179(V) = (1.29)(V)$

$5250 = 1.111\ V$

$V = \frac{5250}{1.111} = 4{,}725\ \text{m}^3$

5. A car company wants to create an ad where their car appears to float on water. The mass of the car is 2000 kg. If Styrofoam has a specific gravity of 0.08 and the wheel base is 2 m wide by 4 m long, how deep must the Styrofoam be to just float the car on the surface of the water? The density of fresh water (D) is 1000 kg/m^3.



$mass_{stuff} = mass_{fluid}$ $\quad$ $V_F = V_w$

$M_{car} + M_{foam} = mass_{water}$

$2000\,kg + D_F \cdot V_F = D_w \cdot V_w$

$2000 + 80(V) = (1000)V$

$2000 = 920V$

$V = \frac{2000}{920} = 2.17\,m^3$

$S.G._{foam} = \frac{D_{Foam}}{D_{water}}$

$.08 = \frac{D_{Foam}}{1000}$ $\quad$ $D_{Foam} = 80\,\frac{kg}{m^3}$

$V = l \times w \times h$

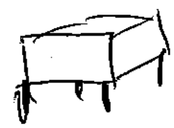
$2.17 = 4 \times 2 \times h$

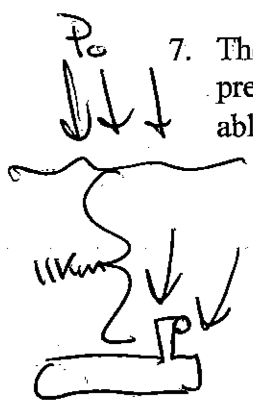
$h = .271\,m = 27.1\,cm$

6. A 1.5 m wide by 2.5 m long water bed weighs 1025 N. Find the pressure that the water bed exerts on the floor. Assume that the entire lower surface makes contact with the floor.

$A = l \times w = 1.5 \times 2.5 = 3.75\,m^2$

$P = \frac{F}{A} = \frac{1025\,N}{3.75\,m^2} = 273.3\,\frac{N}{m^2} = 273.3\,Pa$





7. The Mariana Trench, in the Pacific Ocean, is about 11.0 km deep. If atmospheric pressure at sea level is 1.01 x 10^5 Pa, how much pressure would a submarine need to be able to withstand to reach this depth? The density of sea water (D) is 1025 kg/m^3.

$Pressure = P_o + Dgh$

$1.01 \times 10^5\,Pa + (1025\,\frac{kg}{m^3} \times 9.8\,m/s^2 \times 11{,}000\,m)$

$P = 110{,}596{,}000\,Pa$ $\quad$ $1.106 \times 10^8\,Pa$

8. Water is to be pumped to the top of the Empire State Building, which is 366 m high. What gauge pressure is needed in the water line at the base of the building to raise the water to this height? The density of fresh water (D) is 1000 kg/m^3.

$Gauge\ P = D \times g \times h$

$= 1000\,kg/m^3 \times 9.8\,m/s^2 \times 366\,m = 3{,}586{,}800\,Pa$

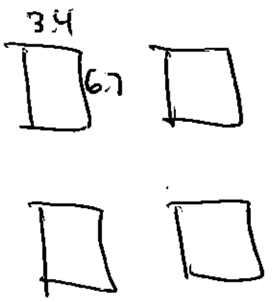
9. When a submarine dives to a depth of 500 m, how much pressure, in Pa, must its hull be able to withstand? How many times larger is the pressure than the pressure at the surface (1.01×10^5 Pa)? The density of sea water (D) is 1025 kg/m^3.

$P = P_o + Dgh = 1.01 \times 10^5 Pa + (1025\ kg/m^3 \times 9.8\ m/s^2 \times 500\ m)$

$P = 5.12 \times 10^6\ Pa$

$\frac{5.12 \times 10^5 Pa}{1.01 \times 10^5 Pa} = 50.7\times$ more pressure

10. What is the weight of a car (in pounds) if each tire is inflated to a pressure of 30.5 lb/in^2 (psi) and each tire has 3.4 inches x 6.7 inches of tire in contact with the ground?



Area of each tire $= 3.4 \times 6.7 = 22.78\ in^2$

$P = \frac{F}{A}$ $F = P \times A = 30.5\ \frac{lb}{in^2} \times 22.78\ in^2 = 694.79\ lbs$ ← Per tire

$694.79 \times 4 = 2779.16\ lbs$

11. Suppose Mr. St. Clair would like to take a trip, only he can't afford to fly on a plane or a blimp. He decides to strap a bunch of 6" balloons to his back. Mr. St. Clair has a weight of 185 lbs. How many 6" (diameter) balloons would he need to inflate? (You should assume that the mass of the balloons aren't affecting the mass of Mr. St)How does this make you think about the movie "Up" where a house was carried through the air via helium balloons.

$Mass_{st} + Mass_{He} = Mass_{air}$

$185\ lbs \left(\frac{1\ kg}{2.2\ lbs}\right) = 84.1\ kg$

$84.1\ kg + D_{He}V_{He} = D_{air}V_{air}$

$d = 6"$ $r = 3" \left(\frac{2.54\ cm}{1\ inch}\right)\left(\frac{1\ m}{100\ cm}\right) = .0762$

$84.1\ kg + (.179\ kg/m^3)(V) = (1.29\ kg/m^3)(V)$

$V_{Balloon} = \frac{4}{3}\pi r^3$

$84.1\ kg = (1.111\ kg/m^3)\ V$

$V = \frac{4}{3}\pi(.0762\ m)^3$

$V = 75.7\ m^3$ ← to lift off ground

$V_{Balloon} = .001853\ m^3$

$\#$ of balloons $= \frac{75.7\ m^3}{.001853\ m^3/balloon}$

40,845 balloons