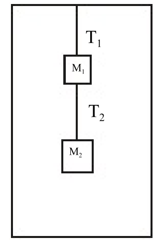
Fluids

WORKSHEET #2

Name: ________________________



1. Two 12.0 kg masses are hanging from the ceiling of an elevator that is accelerating upward at 5.25 m/s^2. What is the tension in each rope?

$F_{net2} = m_2 \cdot a = 12.0\text{ kg} \cdot 5.25\text{ m/s}^2 = 63\text{ N}$
$F_{net2} = T_2 - m_2 g$
$T_2 = F_{net2} + m_2 g = 63\text{ N} + 12.0\text{ kg} \cdot 9.8\text{ m/s}^2 = 180.6\text{ N} = \boxed{181\text{ N}}$
$F_{net1} = m_1 \cdot a = 12.0\text{ kg} \cdot 5.25\text{ m/s}^2 = 63\text{ N}$
$F_{net1} = T_1 - T_2 - m_1 g$
$T_1 = F_{net1} + T_2 + m_1 g = 63\text{ N} + 180.6\text{ N} + 12.0\text{ kg} \cdot 9.8\text{ m/s}^2 = 361.2\text{ N} = \boxed{361\text{ N}}$

2. A solid brass sphere has a diameter of 5.50 cm. It is immersed in water. Find (a) the buoyant force acting on the sphere and (b) the apparent weight of the sphere in the water.

a. $F_b = \rho V g = 1000\text{ kg/m}^3 \cdot 4/3\ \pi\ (0.0225\text{ m})^3 \cdot 9.8\text{ m/s}^2 = 0.4676\text{ N} = \boxed{0.468\text{ N}}$
b. $w_{app} = w - F_b = mg - F_b = (\rho V)g - F_b$
$= 8500\text{ kg/m}^3 \cdot 4/3\ \pi\ (0.0225\text{ m})^3 \cdot 9.8\text{ m/s}^2 - 0.4676\text{ N} = 3.5068878\text{ N} = \boxed{3.51\text{ N}}$

3. A fishing line is attached to one of those bobber deals that is 5.00 cm in diameter and has a mass of 5.00 g. A lead weight is attached to the line. What is the mass of the lead if the bobber is floating half submerged?

$F_{net} = F_b - w_{bobber} - w_{lead} = \rho V_{halfbobber} g - m_{bobber} g - m_{lead} g = 0$ so ...
$\rho V_{halfbobber} g = m_{bobber} g + m_{lead} g$
$\rho(4/3\ \pi\ r^3)/2 = m_{bobber} + m_{lead}$
$m_{lead} = \rho(4/3\ \pi\ r^3)/2 - m_{bobber}$
$= 1000\text{ kg/m}^3 \cdot 4/3\ \pi \cdot (0.025\text{ m})^3/2 - 0.00500\text{ kg} = 0.0277249\text{ kg} = \boxed{27.7\text{ g}}$

4. A solid chunk of iron is floating in mercury. What percent of the iron object is submerged?

% submerged = V_{sub}/V_{tot}
$F_b = w_{iron}$ (if floating)
$\rho_{mercury} \cdot V_{sub} \cdot g = m_{iron} \cdot g$
$\rho_{mercury} \cdot V_{sub} \cdot g = \rho_{iron} \cdot V_{tot} \cdot g$
$V_{sub}/V_{tot} = \rho_{iron}/\rho_{mercury} = 7.8/13.6 = 0.5735 = 0.57 = \boxed{57\%}$

5. This is an urban legend problem. An 85 kg lout decides to go floating aloft in his 4.5 kg lawn chair. He plans to use helium filled balloons to provide buoyancy. He carries along a pellet gun (to shoot out balloons so he can come down later), a six pack, and some sandwiches – total mass is 5.0 kg. A balloon and string has a mass of 40.0 g. He inflates the balloons so that each has a diameter of 68 cm. So, how many balloons does he need to get off the ground?

$m_{balloon} = m_{balloon\&string} + m_{He}$

$= 0.040\text{ kg} + 4/3\pi(0.34\text{ m})^3 \cdot 0.179\text{ kg/m}^3$

$= 0.040\text{ kg} + 0.029\text{ kg} = 0.069\text{ kg}$

$F_b = m_{stuff}\, g + m_{balloons} g$

$n \cdot \rho_{air} \cdot V_{balloon} \cdot g = (85\text{ kg} + 4.5\text{ kg} + 5.0\text{ kg}) \cdot g + n \cdot (0.069\text{ kg}) \cdot g$

$n \cdot \rho_{air} \cdot V_{balloon} = (85\text{ kg} + 4.5\text{ kg} + 5.0\text{ kg}) + n \cdot (0.069\text{ kg})$

$n \cdot 1.29\text{ kg/m}^3 \cdot 4/3\ \pi\ (0.34\text{ m})^3 = 94.5\text{ kg} + n \cdot (0.069\text{ kg})$

$n \cdot 0.2123807\text{ kg} = 94.5\text{ kg} + n \cdot 0.069\text{ kg}$

$n\ (0.2123807\text{ kg} - 0.069\text{ kg}) = 94.5\text{ kg}$

$n\ (0.1433807\text{ kg}) = 94.5\text{ kg}$

$n = 659.1\text{ balloons} = \boxed{\text{660 or more balloons}}$

6. Water flows through a garden hose that has a diameter of 2.50 cm at a speed of 5.25 m/s. What is the speed of the water when it spurts out of a nozzle that has a diameter of 0.120 cm?

$A_1 v_1 = A_2 v_2$

$v_2 = A_1 v_1 / A_2$

$= \pi(0.0125\text{ m})^2 \cdot 5.25\text{ m/s} / \pi(0.00060\text{ m})^2 = 2279\text{ m/s} = \boxed{\text{2280 m/s or 2.28 km/s}}$

7. A spring (k = 185 N/m) is set vertically in a container of water and its end is attached to the bottom of the container. A 5.25 kg block of wood is attached to the top of the spring. The system comes to equilibrium. What is the elongation (ΔL) of the spring?

$F_b = w_{wood} + F_{spring}$

$\rho V g = mg + kx$

$x = (\rho V g - mg)/k = (\rho_{water}(m/\rho_{wood})g - mg)/k$

$= (1000\text{ kg/m}^3 \cdot (5.25\text{ kg} / 500\text{ kg/m}^3) \cdot 9.8\text{ m/s}^2 - 5.25\text{ kg} \cdot 9.8\text{ m/s}^2)/185\text{ N/m}$

$= 0.278108108\text{ m} = \boxed{\text{0.278 m or 27.8 cm}}$

8. A fountain has a pump that shoots a column of water straight up. Figure that there is a large pool of water and the column, which reaches a height of 3.00 m, has a cross sectional area of 125 cm^2 at its base. Find (a) the speed of the water as it leaves the pool, (b) the flow rate of the water, and (c) the power of the pump to do this.

a. Solution 1: Bernoulli's equation

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$ ($P_1 = P_2$ = atmospheric pressure)

$\frac{1}{2}\rho v_1^2 + \rho g y_1 = \frac{1}{2}\rho v_2^2 + \rho g y_2$ (divide both sides by ρ)

$\frac{1}{2}v_1^2 + g y_1 = \frac{1}{2}v_2^2 + g y_2$

$0.5\, v_1^2 + 9.8\ m/s^2 \cdot 0\ m = 0.5\,(0\ m/s)^2 + 9.8\ m/s^2 \cdot 3m$

$v_1 = (2 \cdot 9.8\ m/s^2 \cdot 3\ m)^{\frac{1}{2}} = 7.6681158\ m/s = \boxed{7.67\ m/s}$

Solution 2: Use work/energy

$\frac{1}{2}mv^2 = mgh$

$v = (2gh)^{\frac{1}{2}} = (2 \cdot 9.8\ m/s^2 \cdot 3\ m)^{\frac{1}{2}} = 7.6681158\ m/s = \boxed{7.67\ m/s}$

b. Flow $= V/t = Av = 0.0125\ m^2 \cdot 7.67\ m/s = 0.095875\ m^3/s = \boxed{0.0959\ m^3/s}$

$0.095875\ m^3/s \cdot 1000\ L/m^3 \cdot 60\ s/min = 5752.5\ L/min = \boxed{5750\ L/min}$

c. $P = mgh/t = (95.9\ kg \cdot 9.8\ m/s^2 \cdot 3\ m)/1s = 2819.46\ W = \boxed{2820\ W \text{ or } 2.82\ kW}$

or

$P = (\frac{1}{2}mv^2)/t = 0.5 \cdot 95.9\ kg \cdot (7.6681158\ m/s)^2 = 2819.46\ W = \boxed{2820\ W \text{ or } 2.82\ kW}$