

# Physics 260 Homework Assignment 1

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## 1 PSE6 14.CQ.004

We take the atmosphere pressure to be  $P = P_0 = 1.00\text{atm} = 1.013 \times 10^5\text{Pa}$ . The weight of the air above the head is the same as the force that pushes down on the head. Therefore,  $W = F$ . Using the definition of pressure,  $P = \frac{F}{A}$ , we have

$$F = PA = (1.013 \times 10^5\text{Pa})(1 \times 10^{-2}\text{m}^2) = 1.013 \times 10^3\text{N}$$

## 2 PSE6 14.CQ.030

a. The fluid with the greatest density will sink to the bottom of the glass and the fluid with the lowest density will float on the top. Therefore, oil has the lowest density and mercury has the greatest density.

b. The density of the object increases from top to bottom.

## 3 PSE6 14.P.001

Given the diameter of the iron sphere  $d$ , we can calculate the volume of the sphere  $V = \frac{4}{3}\pi(\frac{d}{2})^3$ . The density of iron is given in Table 14.1 in the textbook,  $\rho_{\text{iron}} = 7.86 \times 10^3\text{kg/m}^3$ . Therefore, the mass of the solid iron sphere can be found using

$$m = \rho_{\text{iron}}V = \rho_{\text{iron}}\frac{4}{3}\pi(\frac{d}{2})^3 = \frac{1}{6}\rho_{\text{iron}}\pi d^3$$

## 4 PSE6 14.P.003

If the heel has a radius of  $r$ , then the cross-sectional area would be  $\pi r^2$ . And the force acting on the heel is the weight of the woman. Hence, the pressure exerted on the floor is

$$P = \frac{F}{A} = \frac{mg}{\pi r^2}$$

## 5 PSE6 14.P.004

Let  $F_g$  be the weight of the automobile. Then each tire supports  $\frac{F_g}{4}$ , so

$$P = \frac{F}{A} = \frac{F_g}{4A}$$

Rearrange the terms yields,

$$F_g = 4AP$$

## 6 PSE6 14.P.006

a. The absolute pressure is given by the equation  $P = P_0 + \rho gh$ , where  $P_0$  is taken to be  $1.013 \times 10^5 \text{ pa}$ .

b. The gauge pressure is the difference in pressure between the water outside and the air inside the submarine, which is at 1.00 atmosphere.

$$P_{gauge} = P - P_0 = \rho gh$$

The resultant inward force on the porthole is then

$$F = P_{gauge}A = P_{gauge}\pi\left(\frac{d}{2}\right)^2$$

## 7 PSE6 14.P.008

Since the pressure is the same on both sides, we have

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

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

## 8 PSE6 14.P.018

a. Using the definition of density, we have

$$h_w = \frac{m_{water}}{A_2 \rho_{water}}$$

b. Figure 1b represents the situation after the water is added. Since the volume of mercury stays the same, the volume of the mercury that is displaced by water in the right tube equals the additional volume gained by the left tube.

Hence,  $A_1 h = A_2 h_2$ , or  $h_2 = \frac{A_1}{A_2} h$ . At the level of the mercury-water interface in the right tube, we may write the absolute pressure as:

$$P_2 = P_0 + \rho_{water} g h_w$$

The pressure at the same level in the left tube is given by

$$P_1 = P_0 + \rho_{mercury} g (h + h_2) = P_0 + \rho_{mercury} g \left( h + \frac{A_1}{A_2} h \right) = P_0 + \rho_{mercury} g \left( 1 + \frac{A_1}{A_2} \right) h$$

Since  $P_1 = P_2$ , we can set the above two equations equal and cancel out  $P_0$  and  $g$ . It yields

$$h = \frac{\rho_{water} h_w}{\rho_{mercury} \left( 1 + \frac{A_1}{A_2} \right)}$$

## 9 PSE6 14.P.025

a. before the metal is immersed in the water, the forces acting on it are upward tension  $T_1$  and downward gravitational force  $Mg$ . Since the metal is in equilibrium, these two forces should cancel each other. Therefore,  $T_1 = Mg$ .

b. after the metal is immersed in the water, the downward force acting on it is still the gravitational force  $Mg$ . The upward forces include buoyant force  $\mathbf{B}$  due to water and tension  $T_2$  provided by the string. Again, the metal is in equilibrium in the water. So the upward force should equal to the downward force in magnitude.

$$\mathbf{B} + T_2 = Mg$$

Also,  $\mathbf{B} = \rho_{water} g V_{Al}$ . We can find the volume of metal  $V_{Al}$  by dividing the mass of metal by the density of the metal. Plug both equations into the equilibrium equation,  $T_2$  can then be determined.

## 10 PSE6 14.P.029

a. Assume the distance from the horizontal top surface of the cube to the water level is  $h$  and the length of each edge of the cube is  $l$ . The volume of the wood that is immersed in the water is  $V_{im} = l^2(l - h)$ . Only gravitational force and buoyant force act on the wood. Set two values equal yields

$$Mg = \mathbf{B} = \rho_{water} g V_{im} = \rho_{water} g l^2(l - h)$$

Solve for  $h$ .

b. After adding lead, the forces acting on the whole system are still the same except we need to include the weight of the lead when we consider the gravitational force. Therefore,

$$(M_{wood} + M_{lead})g = \mathbf{B} = \rho_{water} g V_{im} = \rho_{water} g l^3$$

Solve for  $M_{lead}g$  for the weight.

## 11 PSE6 14.P.034

Similar to the previous problem, we have

$$M_{frog}g = \mathbf{B} = \rho_{water}gV_{im} = \rho_{water}g\left(\frac{1}{2}\frac{4}{3}\pi r^3\right)$$

Solve for  $M_{frog}$ .

## 12 PSE6 14.P.036

Constant velocity implies zero acceleration, which means the net force acting on the submarine is zero. The downward forces are due to the mass of the submarine  $m_1$  and the mass of the seawater  $m_2$  it takes on. The upward forces include the buoyant force  $\mathbf{B}$  and the resistive force  $\mathbf{F}_R$ . Hence

$$(m_1 + m_2)g = \mathbf{B} + \mathbf{F}_R$$

Also,

$$\mathbf{B} = \rho_{water}g\frac{4}{3}\pi r^3$$

Combine two equations and solve for  $m_2$ .