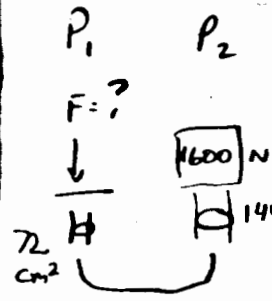
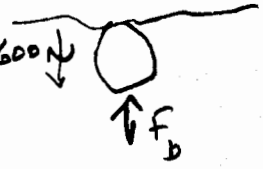
Fluid Pressure and Force

1. Dentists' chairs are examples of hydraulic lift systems. If the chair weighs 1600 N and rests on a piston with a cross-sectional area of 1440 cm2, what force must be applied to the small piston with a cross-sectional area of 72 cm2 to lift the chair?



$P_1 = P_2$ $\quad \frac{F_1}{A_1} = \frac{F_2}{A_2}$ $\quad \frac{F_1}{72\,cm^2} = \frac{1600N}{1440\,cm^2}$ $\quad F_1 = 8.0 \times 10^1\ N$

2. A teenager is floating in a freshwater lake with her head just above the water. If she weighs 600 N, what is the volume of the submerged part of her body



$F_R = F_W - F_b$ $\quad 0 = 600N - F_b$ $\quad F_b = 600N$ $\quad F_W = m\,g$ $\quad 600N = m\,9.8$ $\quad m = 61.22\,kg$ $\quad d = \frac{m}{V}$ $\quad V = \frac{m}{d}$

$= 61.22\,kg \times \frac{1000\,g}{1\,kg} \times \frac{1\,cm^3}{1\,g} = 6.12 \times 10^4\,cm^3$

3. A 75 kg solid cylinder, 2.5 m long and with an end radius of 5 cm, stands on one end. How much pressure does it exert?

$A = \pi r^2$ $\quad F = m\,a$ $\quad = 75\,kg\ 9.8 = 735N$

$P = \frac{F}{A} = \frac{735\,N}{78.5\,cm^2} = 9.36\,\frac{N}{cm^2}$ $\quad 3.14(5cm)^2$

4. A hydraulic lift is used to raise heavy equipment for repairs. The system has a small piston with a cross-sectional area of 7 x 10 –2 m2. An engine weighing 2.7 x 10 3 N rests on the large piston. What force must be applied to the small piston in order to lift the engine? A_2 = TWICE THE AREA.

$d = \frac{m}{V}$ $\quad 0.81 = \frac{m}{1.96}$ $\quad m = 1.59 \times 10^{-3}$

5. A test tube standing vertically in a test tube rack contains 2.5 cm of oil (d=0.81 g/cm3) and 6.5 cm of water. What is the pressure on the bottom of the tube?

$V_o = h\pi r^2 = 2.5(3.14)(.5)^2 = 1.96cm^3$ $\quad W_o = 0.0156N$

$W_o = 1.59 \times 10^{-3}(9.8)$ $\quad V = 6.5(3.14)(.5)^2 = 5.10cm^3$ $\quad \frac{1g}{cm^3} = \frac{m}{5.1cm^3}$ $\quad m = 5.1 \times 10^{-3}$ $\quad W_W = 0.05N$

$W_T = 0.05 + 0.0156 = 0.0656N$

$P = \frac{0.0656}{0.785}$ $\quad d = 1cm$

$P = 8.36 \times 10^{-2}\,\frac{N}{cm^2}$

6. A metal object is suspended from a spring scale. The scale reads 920 N when the object is suspended in air, and 750 N when the object is completely submerged in water. Find the volume of the object and then find the density

$F_R = F_W - F_b$ $\quad 750 = 920 - F_b$ $\quad F_b = 170N$ $\quad W_w = 170N$ $\quad 170N = m(9.8)$ $\quad m_w = 17.35kg$

$V = \frac{m}{d} = 17.35kg \times \frac{1m^3}{1000kg} = 0.0174m^3$

$920 = m\,9.8$ $\quad m = 93.88kg$ $\quad d = 5.40 \times 10^3\,\frac{kg}{m^3}$

7. A cubic decimeter (10 –3 m3) of steel is submerged in water.

a. What is the magnitude of the buoyant force acting on the steel?

$F_b = m\,g = 1kg(9.8) = 9.8N$ $\quad d = \frac{m}{V}$ $\quad 1 \times 10^{-3}m^3 = \frac{m}{1000kg/m^3}$ $\quad m = 1kg$

b. What is the apparent weight of the body? (d= 9 x 103 kg/m3)

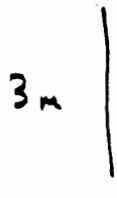
$F_R = F_W - F_b = 88.2N - 9.8N = 7.84 \times 10^1\,N$ $\quad d = \frac{m}{V}$ $\quad 9 \times 10^3 = \frac{m}{1 \times 10^{-3}m^3} = 9kg$

$F_W = 9(9.8) = 88.2N$

c. Find the acceleration of the steel as it sinks in the water.

$F = m\,a$ $\quad 78.4N = 9kg\,a$ $\quad a = 8.71\,m/s^2$

d. How long would it take to reach the bottom of a swimming pool 3 m deep?



$t = ?$ $\quad y = V_i t + \frac{1}{2}at^2$

$3m = 0 + \frac{1}{2}\,8.71\,t^2$

$t = 0.83\,s$