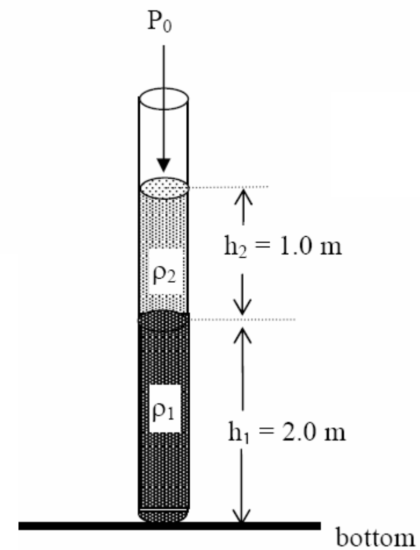
Selected Problems from Chapter 14

1) The open vertical tube in FIGURE contains two liquids of densities Rho1 = 1000 kg/m**3 and Rho2 = 600 kg/m**3, Which do not mix. Find the PRESSURE (in N/m**2) at the bottom of the tube.

A1 1.3* 10**5
A2 1.9* 10**4
A3 2.1* 10**4
A4 3.7* 10**5
A5 0.3* 10**4



$$P = P_0 + \rho_2 g h_2 + \rho_1 g h_1$$

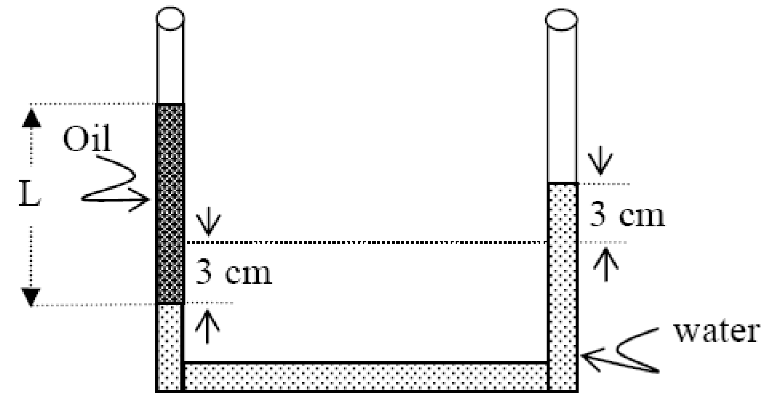
$$= 1.01\times10^5 + 10^3 \times 9.8 \times 1.0 + 600 \times 9.8 \times 2.0$$

$$= 1.01\times10^5 + 0.098\times10^5 + 0.1176\times10^5$$

$$\approx 1.2\times10^5 \; N.m$$

2) A uniform U-tube is partially filled with water. Oil, of density 0.75 g/cm**3, is poured into the left arm until the water level in the right arm rises 3 cm (see Fig.). The length of the oil column, L, is then:

A1 8 cm
A2 2 cm
A3 6 cm
A4 4 cm
A5 10 cm



$$P_0 + \rho_o g L = P_0 + \rho_w g\,(0.06)$$

$$\rho_o L = \rho_w\,(0.06)$$

$$0.75 \times L = 1.0 \times 0.06$$

$$L = \frac{0.06}{0.75} = \frac{6}{75} = 0.08\,m$$

3) An object hangs from a spring balance. The balance indicates 30 N in air, 20 N when the object is completely submerged in water, and 24 N when the object is completely submerged in an unknown liquid. The density of the unknown liquid equals :

A1 0.6 g/cm**3
A2 2.5 g/cm**3
A3 1.2 g/cm**3
A4 0.4 g/cm**3
A5 0.3 g/cm**3

$$W = mg = 30\ N$$

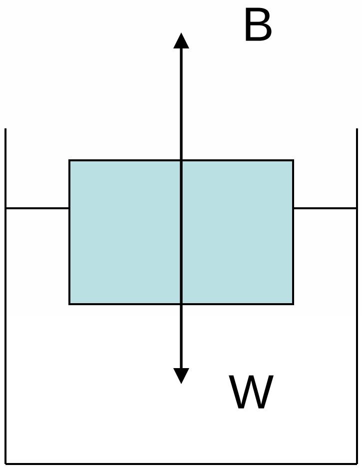
$$W - B_{water} = 20\ N \Rightarrow B_{water} = 10\ N = \rho_w V g \quad (1)$$

$$W - B_{liquid} = 24\ N \Rightarrow B_{liquid} = 6\ N = \rho_{liquid} V g \quad (2)$$

$$devide\ (2)\ by\ (1) \Rightarrow \frac{\rho_{liquid}}{\rho_w} = \frac{6}{10} \Rightarrow \rho_{liquid} = 0.6\ g/cm^3$$

4) A block of wood floats in water with two-third of its volume submerged. Find the DENSITY of the wood (in kg/m**3). (Density of water is 1.0* 10**3 kg/m**3).

A1 667
A2 1500
A3 1000
A4 500
A5 333



$$W = B \ (floating)$$

$$\rho_{wood} V g = \rho_{water} (\tfrac{2}{3} V) g$$

$$\rho_{wood} = \tfrac{2}{3} \rho_{water} = \tfrac{2}{3} \times 1.0 \times 10^3 = 667 \ kg/m^3$$

5) The rate of flow of water through a horizontal pipe is 2.0 m**3/minute. Determine the SPEED of flow at a point where the radius of the pipe is 5.0 cm.

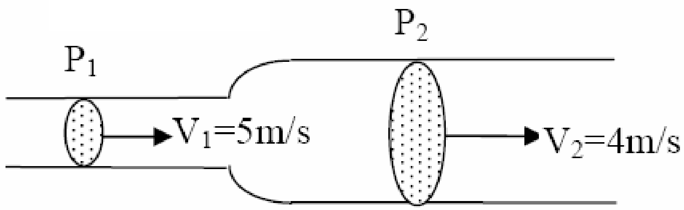
A1 4.2 m/s
A2 2.0 m/s
A3 6.0 m/s
A4 5.3 m/s
A5 7.2 m/s

$$\text{volume rate} = R_V = Av$$

$$\frac{2.0}{60}\, m^3/s = (\pi R^2)v = (\pi \times 0.05^2)v$$

$$v = 4.2\ m/s$$

6) Water (density = 1.0 x 10**3 kg/m**3) flows through a horizontal pipe as shown in FIGURE . At the wider end its speed is 4.0 m/s and at the narrow end its speed is 5.0 m/s. The DIFFERENCE in pressure, P2 - P1, between the two ends is:



A1 +4.5 x 10**3 Pa
A2 -4.5 x 10**3 Pa
A3 +7.0 x 10**2 Pa
A4 -7.0 x 10**2 Pa
A5 0.0 Pa

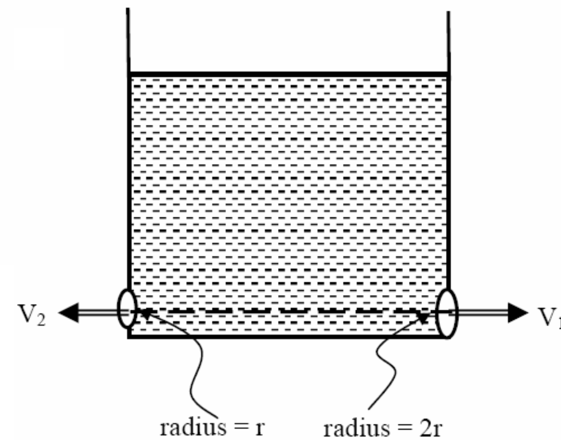
$$P_1 + \frac{1}{2}\rho v_1{}^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2{}^2 + \rho g y_2 \quad (y_1 = y_2)$$

$$P_1 + \frac{1}{2}\rho v_1{}^2 = P_2 + \frac{1}{2}\rho v_2{}^2$$

$$P_2 - P_1 = \frac{1}{2}\rho(v_1{}^2 - v_2{}^2) = \frac{1}{2}\times 10^3 \times (5^2 - 4^2) = \frac{9}{2}\times 10^3\ Pa = 4.5\times 10^3\ Pa$$

7) A large open tank filled with water has two small holes in its bottom, one with twice the radius of the other (see Fig.). In steady flow, the speed of water leaving the larger hole is v1 and the speed of the water leaving the smaller hole is v2. Which of the following statements is correct?

A1 v1 = v2
A2 v1 = 2 v2
A3 v1 = v2 / 2
A4 v1 = v2 / 4
A5 v1 = 4 v2



$$v = \sqrt{2gh}$$

v *depends only on the hieght of the water from the holes*

$$\Rightarrow v_1 = v_2$$

•4 A partially evacuated airtight container has a tight-fitting lid of surface area 77 m^2 and negligible mass. If the force required to remove the lid is 480 N and the atmospheric pressure is 1.0×10^5 Pa, what is the air pressure in the container before it is opened?

4. The magnitude F of the force required to pull the lid off is $F = (p_o - p_i)A$, where p_o is the pressure outside the box, p_i is the pressure inside, and A is the area of the lid. Recalling that $1\text{N/m}^2 = 1$ Pa, we obtain

$$p_i = p_o - \frac{F}{A} = 1.0\times10^5 \text{ Pa} - \frac{480 \text{ N}}{77\times10^{-4} \text{ m}^2} = 3.8\times10^4 \text{ Pa}.$$

•9 Calculate the hydrostatic difference in blood pressure between the brain and the foot in a person of height 1.83 m. The density of blood is 1.06×10^3 kg/m^3.

9. We estimate the pressure difference (specifically due to hydrostatic effects) as follows:

$$\Delta p = \rho g h = (1.06 \times 10^3 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(1.83 \text{ m}) = 1.90 \times 10^4 \text{ Pa}.$$

13 The plastic tube in Fig. 14-30 has a cross-sectional area of 5.00 cm^2. The tube is filled with water until the short arm (of length d = 0.800 m) is full. Then the short arm is sealed and more water is gradually poured into the long arm. If the seal will pop off when the force on it exceeds 9.80 N, what total height of water in the long arm will put the seal on the verge of popping?

Fig. 14-30 Problems 13 and 67.

13. With $A = 0.000500 \text{ m}^2$ and $F = pA$ (with p given by Eq. 14-9), then we have ρghA = 9.80 N. This gives $h \approx 2.0$ m, which means $d + h = 2.80$ m.

•25 An iron anchor of density 7870 kg/m^3 appears 200 N lighter in water than in air. (a) What is the volume of the anchor? (b) How much does it weigh in air? SSM

25. (a) The anchor is completely submerged in water of density ρ_w. Its effective weight is $W_{\text{eff}} = W - \rho_w gV$, where W is its actual weight (mg). Thus,

$$V = \frac{W - W_{\text{eff}}}{\rho_w g} = \frac{200 \text{ N}}{\left(1000 \text{ kg/m}^3\right)\left(9.8 \text{ m/s}^2\right)} = 2.04 \times 10^{-2} \text{ m}^3 .$$

(b) The mass of the anchor is $m = \rho V$, where ρ is the density of iron (found in Table 14-1). Its weight in air is

$$W = mg = \rho V g = \left(7870 \text{ kg/m}^3\right)\left(2.04 \times 10^{-2} \text{ m}^3\right)\left(9.80 \text{ m/s}^2\right) = 1.57 \times 10^3 \text{ N} .$$

••35 An iron casting containing a number of cavities weighs 6000 N in air and 4000 N in water. What is the total volume of all the cavities in the casting? The density of iron (that is, a sample with no cavities) is 7.87 g/cm^3. SSM

35. The volume V_{cav} of the cavities is the difference between the volume V_{cast} of the casting as a whole and the volume V_{iron} contained: $V_{cav} = V_{cast} - V_{iron}$. The volume of the iron is given by $V_{iron} = W/g\rho_{iron}$, where W is the weight of the casting and ρ_{iron} is the density of iron. The effective weight in water (of density ρ_w) is $W_{eff} = W - g\rho_w V_{cast}$. Thus, $V_{cast} = (W - W_{eff})/g\rho_w$ and

$$V_{cav} = \frac{W - W_{eff}}{g\rho_w} - \frac{W}{g\rho_{iron}} = \frac{6000\text{ N} - 4000\text{ N}}{(9.8\text{ m/s}^2)(1000\text{ kg/m}^3)} - \frac{6000\text{ N}}{(9.8\text{ m/s}^2)(7.87\times10^3\text{ kg/m}^3)}$$

$$= 0.126\text{ m}^3 .$$

••43 Water is pumped steadily out of a flooded basement at a speed of 5.0 m/s through a uniform hose of radius 1.0 cm. The hose passes out through a window 3.0 m above the waterline. What is the power of the pump? SSM

43. Suppose that a mass Δm of water is pumped in time Δt. The pump increases the potential energy of the water by Δmgh, where h is the vertical distance through which it is lifted, and increases its kinetic energy by $\frac{1}{2}\Delta mv^2$, where v is its final speed. The work it does is $\Delta W = \Delta mgh + \frac{1}{2}\Delta mv^2$ and its power is

$$P = \frac{\Delta W}{\Delta t} = \frac{\Delta m}{\Delta t}\left(gh + \frac{1}{2}v^2\right).$$

Now the rate of mass flow is $\Delta m/\Delta t = \rho_w Av$, where ρ_w is the density of water and A is the area of the hose. The area of the hose is $A = \pi r^2 = \pi(0.010\text{ m})^2 = 3.14\times10^{-4}\text{ m}^2$ and

$$\rho_w Av = (1000\text{ kg/m}^3)\,(3.14\times10^{-4}\text{ m}^2)\,(5.00\text{ m/s}) = 1.57\text{ kg/s}.$$

Thus,

$$P = \rho Av\left(gh + \frac{1}{2}v^2\right) = (1.57\text{ kg/s})\left((9.8\text{ m/s}^2)(3.0\text{ m}) + \frac{(5.0\text{ m/s})^2}{2}\right) = 66\text{ W}.$$

•46 The intake in Fig. 14-44 has cross-sectional area of 0.74 m^2 and water flow at 0.40 m/s. At the outlet, distance D = 180 m below the intake, the cross-sectional area is smaller than at the intake and the water flows out at 9.5 m/s. What is the pressure difference between inlet and outlet?

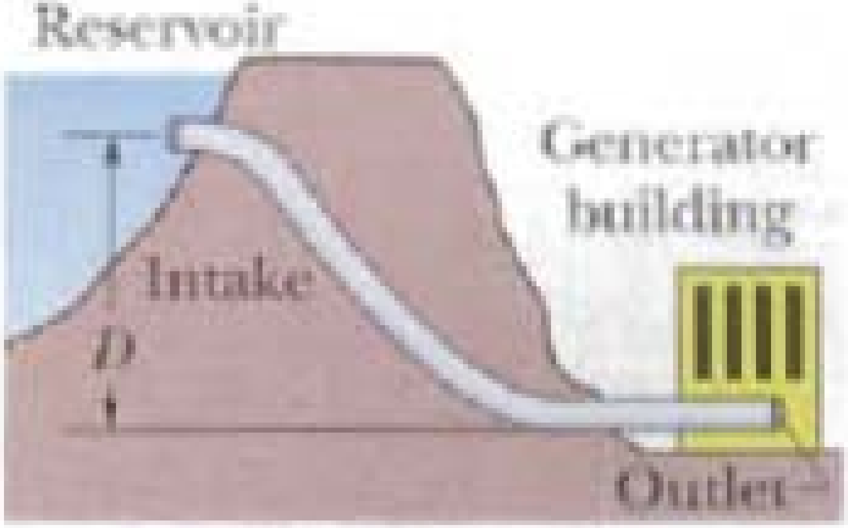


Fig. 14-44 Problem 46.

46. We use Bernoulli's equation:

$$p_2 - p_i = \rho g D + \frac{1}{2}\rho\left(v_1^2 - v_2^2\right)$$

where ρ = 1000 kg/m^3, D = 180 m, v_1 = 0.40 m/s and v_2 = 9.5 m/s. Therefore, we find Δp = 1.7×10^6 Pa, or 1.7 MPa. The SI unit for pressure is the Pascal (Pa) and is equivalent to N/m^2.