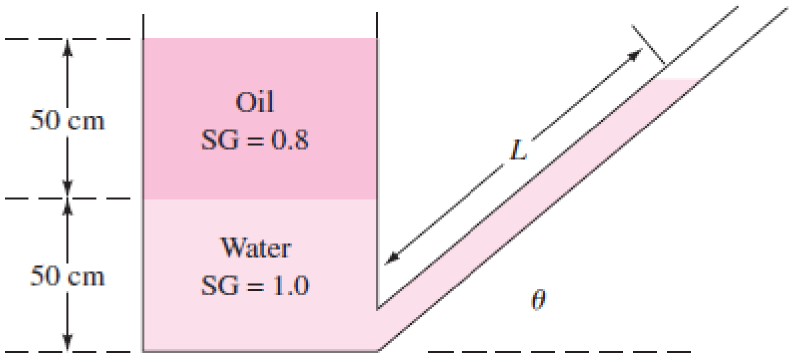
Fluid Mechanics and Rate Processes: Fluid Statics Tutorial: August 04, 2016

(Question are adopted from Chap 2, Fluid Mechanics, F. M. White, 7th Ed.)

P2.41. In Fig. P 2.41 both the tank and the tube are open to the atmosphere. If L 2.13 m, what is the angle of tilt θ of the tube?



P 2.41

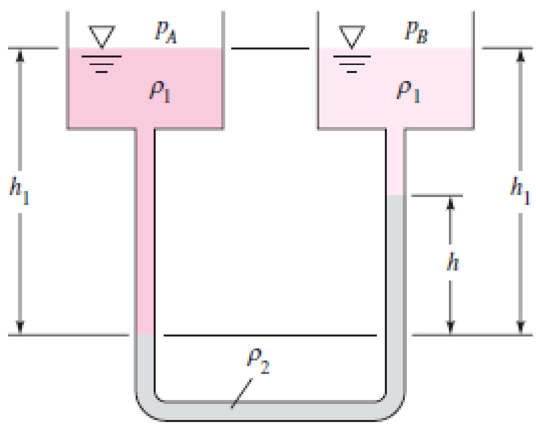
Solution. Proceed hydrostatically from the oil surface to the slanted tube surface:

$$P_a + 0.8(9790)(0.5) + 9790(0.5) - 9790(2.13\sin\theta) = P_a,$$

$$or: \sin\theta = \frac{8811}{20853} = 0.4225,$$

$$\theta \approx 25^\circ \qquad \text{Ans.}$$

P2.47. Very small pressure differences $P_A - P_B$ can be measured accurately by the two-fluid differential manometer in Fig. P2.47. Density ρ_2 is only slightly larger than that of the upper fluid ρ_1. Derive an expression for the proportionality between h and $P_A - P_B$ if the reservoirs are very large.



P 2.47

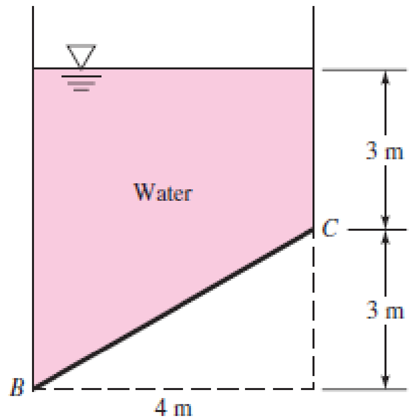
Solution. Apply the hydrostatic formula from A to B:

$$P_A + \rho_1 g h_1 - \rho_2 g h - \rho_1 g (h_1 - h) = P_B$$

$$\text{Solve for, } \quad P_A - P_B = (\rho_2 - \rho_1) g h \qquad \text{Ans.}$$

If $(\rho_2 - \rho_1)$ is very small, h will be very large for a given Δp (a sensitive manometer).

P2.63. The tank in Fig. P2.63 is 2 m wide into the paper. Neglecting atmospheric pressure, find the resultant hydrostatic force on panel *BC* (*a*) from a single formula and (*b*) by computing horizontal and vertical forces separately, in the spirit of Section 2.6.



P 2.63

Solution: (a) The resultant force F, may be found by simply applying the hydrostatic relation

$F = \gamma h_{CG} A = (9790 N/m^3)(3 + 1.5m)(5m \times 2m) = 440{,}550 N = 441 kN$ **Ans. (a)**

(b) The horizontal force acts as though BC were vertical, thus h_{CG} is halfway down from C and acts on the projected area of BC.

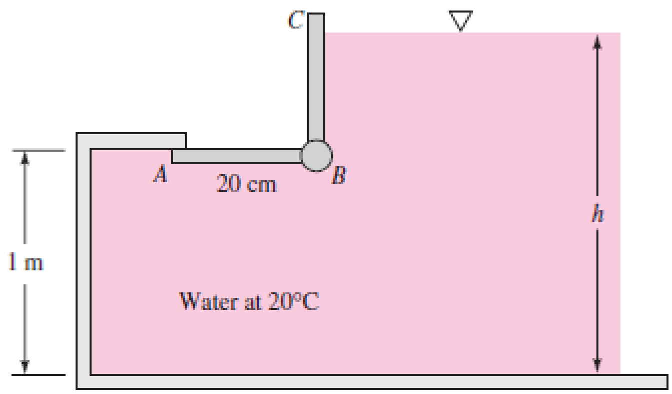
$F_H = (9790)(4.5)(3 \times 2) = 264{,}330 N = 264 kN$ **Ans. (b)**

The vertical force is equal to the weight of fluid above BC,

$F_V = (9790)[(3)(4) + (1/2)(4)(3)](2) = 352{,}440 N = 352 kN$ **Ans. (b)**

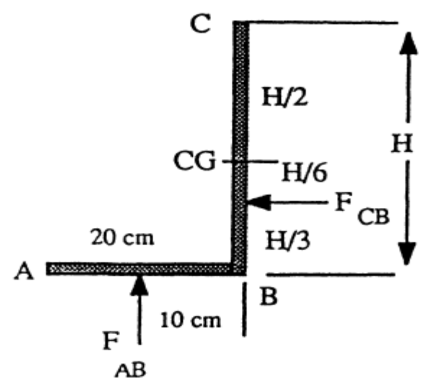
The resultant is the same as part (a): $F = [(264)^2 + (352)^2]^{(1/2)} = 441 kN$

P2.71. Gate *ABC* in Fig. P2.71 has a fixed hinge line at *B* and is 2 m wide into the paper. The gate will open at *A* to release water if the water depth is high enough. Compute the depth *h* for which the gate will begin to open.



P 2.71

Solution. Let H = (h − 1 meter) be the depth down to the level AB. The forces on AB and BC are shown in the free body at below. The moments of these forces about B are equal when the gate opens:



$$\sum M_B = 0 = \gamma H(0.2)b(0.1)$$

$$= \gamma\left(\frac{H}{2}\right)(Hb)\left(\frac{H}{3}\right)$$

$$\text{Or,}\quad H = 0.346m,$$

$$h = H + 1 = 1.346m, \qquad \textbf{Ans.}$$

This solution is independent of both the water density and the gate width b into the paper.