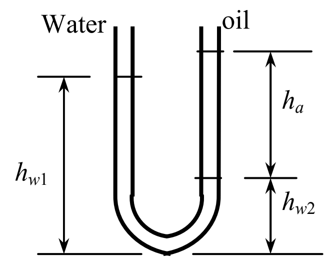
2-61 Water is poured into the U-tube from one arm and oil from the other arm. The water column height in one arm and the ratio of the heights of the two fluids in the other arm are given. The height of each fluid in that arm is to be determined.

Assumptions Both water and oil are incompressible substances.

Properties The density of oil is given to be ρ = 790 kg/m^3. We take the density of water to be ρ =1000 kg/m^3.

Analysis The height of water column in the left arm of the monometer is given to be h_{w1} = 0.70 m. We let the height of water and oil in the right arm to be h_{w2} and h_a, respectively. Then, $h_a = 4h_{w2}$. Noting that both arms are open to the atmosphere, the pressure at the bottom of the U-tube can be expressed as



$$P_{\text{bottom}} = P_{\text{atm}} + \rho_{\text{w}} g h_{\text{w1}} \quad \text{and} \quad P_{\text{bottom}} = P_{\text{atm}} + \rho_{\text{w}} g h_{\text{w2}} + \rho_{\text{a}} g h_{\text{a}}$$

Setting them equal to each other and simplifying,

$$\rho_{\text{w}} g h_{\text{w1}} = \rho_{\text{w}} g h_{\text{w2}} + \rho_{\text{a}} g h_{\text{a}} \quad \rightarrow \quad \rho_{\text{w}} h_{\text{w1}} = \rho_{\text{w}} h_{\text{w2}} + \rho_{\text{a}} h_{\text{a}} \quad \rightarrow \quad h_{\text{w1}} = h_{\text{w2}} + (\rho_{\text{a}} / \rho_{w}) h_{\text{a}}$$

Noting that $h_a = 4h_{w2}$, the water and oil column heights in the second arm are determined to be

$$0.7 \text{ m} = h_{w2} + (790/1000)\, 4h_{w2} \quad \rightarrow \quad h_{w2} = \mathbf{0.168\ m}$$

$$0.7 \text{ m} = 0.168 \text{ m} + (790/1000) h_a \quad \rightarrow \quad h_a = \mathbf{0.673\ m}$$

Discussion Note that the fluid height in the arm that contains oil is higher. This is expected since oil is lighter than water.