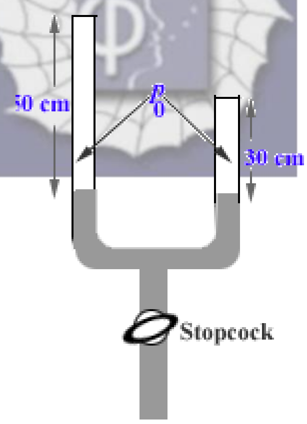
**209.**

**Problem 23.16 (RHK)**

*A mercury-filled manometer with two unequal-length arms of the same cross-sectional area is sealed off with the same pressure* $p_0$ *in the two arms. With the temperature constant, an additional* $10.0\text{ cm}^3$ *of mercury is admitted through the stopcock at the bottom. The level on the left increases* 6.0 cm *and that on the right increases* 4.0 cm. *We have to find the pressure* $p_0$.




**Solution:**

Let the cross-sectional area of the arms of the manometer be $a\text{ cm}^2$. The initial volume of the gas in the left-arm of the manometer will be

$V_l = 50a\text{ cm}^3$,

and the initial volume of the right-arm of the manometer will be

$V_r = 30a\ \text{cm}^3.$

It is given that the pressure of gas in both arms of the manometer is $p_0$.

When at constant initial temperature an additional $10.0\ \text{cm}^3$ of mercury is introduced in the manometer it is given that the level of mercury in the left-arm rises by 6.0 cm and that in the right-arm by 4.0 cm. The changed volume of the gas in the left-arm after mercury has been added will be

$V_l' = 44a\ \text{cm}^3,$

and the changed volume of the gas in the right-arm will be

$V_r' = 26a\ \text{cm}^3.$

Let the changed pressure in the left-arm be $p_l'$ and that in the right-arm be $p_r'$. As the temperature has remained constant in the process, we have

$44 p_l' = 50 p_0$ ,

or

$$p_l' = \frac{50}{44} p_0.$$

Similarly, we have

$$26\,p_r' = 30\,p_0\ ,$$

or

$$p_r' = \frac{30}{26}\,p_0 .$$

We now require that at the same level of mercury in both the arms of the manometer the pressure has to be equal. This gives the condition

$$p_l' + \rho g \times 6\times10^{-2} = p_r' + \rho g \times 4\times10^{-2},$$

or

$$\left(p_r' - p_l'\right) = \rho g \times 2\times10^{-2},$$

or

$$p_0\left(\frac{30}{26} - \frac{50}{44}\right) = 13.6\times10^{3}\times9.8\times2\times10^{-2}\ \text{Pa},$$

or

$$p_0 = 1.52\times10^{5}\ \text{Pa} = 1.5\ \text{atm}.$$