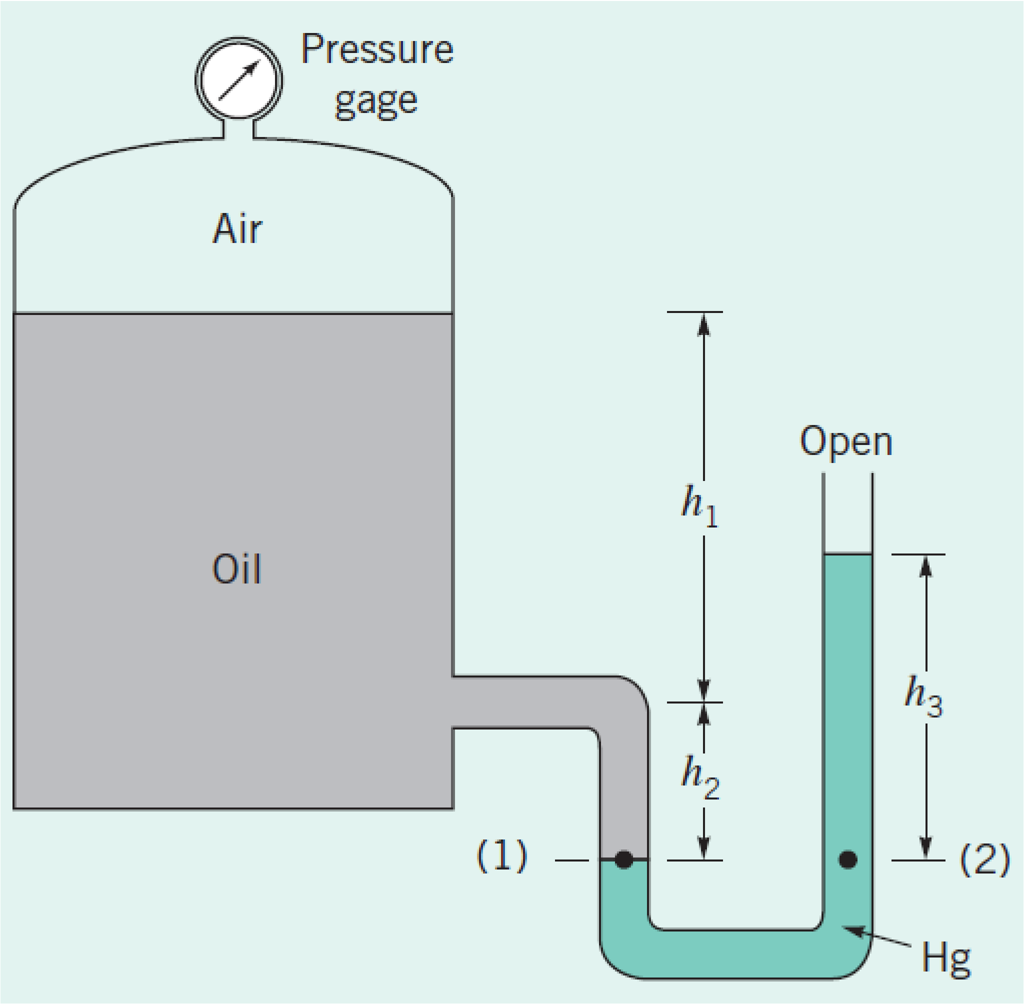
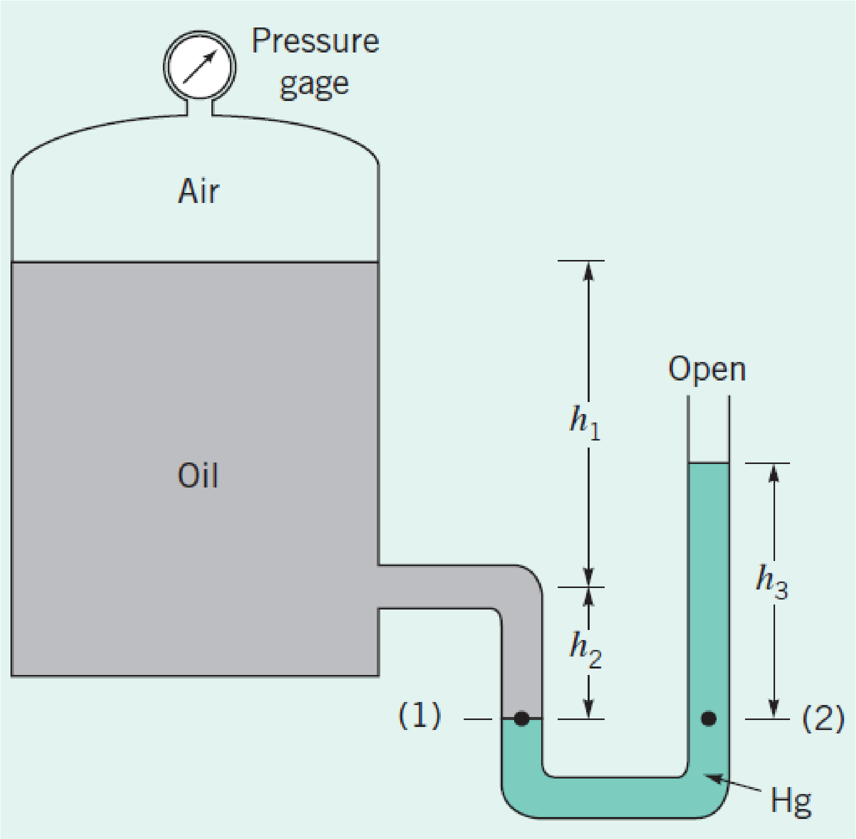
2-4: A closed tank contains compressed air and oil ($SG_{oil} = 0.90$). A U-tube manometer using mercury (SG_{Hg} =13.6) is connected to the tank as shown. The column heights are h_1 =91.4 cm, h_2 =15.2 cm, and $h_3 = 22.9\ cm$. Determine the pressure reading of the gage.





The pressure at level 1:

$$P_1 = P_{air} + \gamma_{oil} \times (h_1 + h_2) = P_2$$

$$P_{air} + \gamma_{oil} \times (h_1 + h_2) - \gamma_{Hg} \times h_3 = 0$$

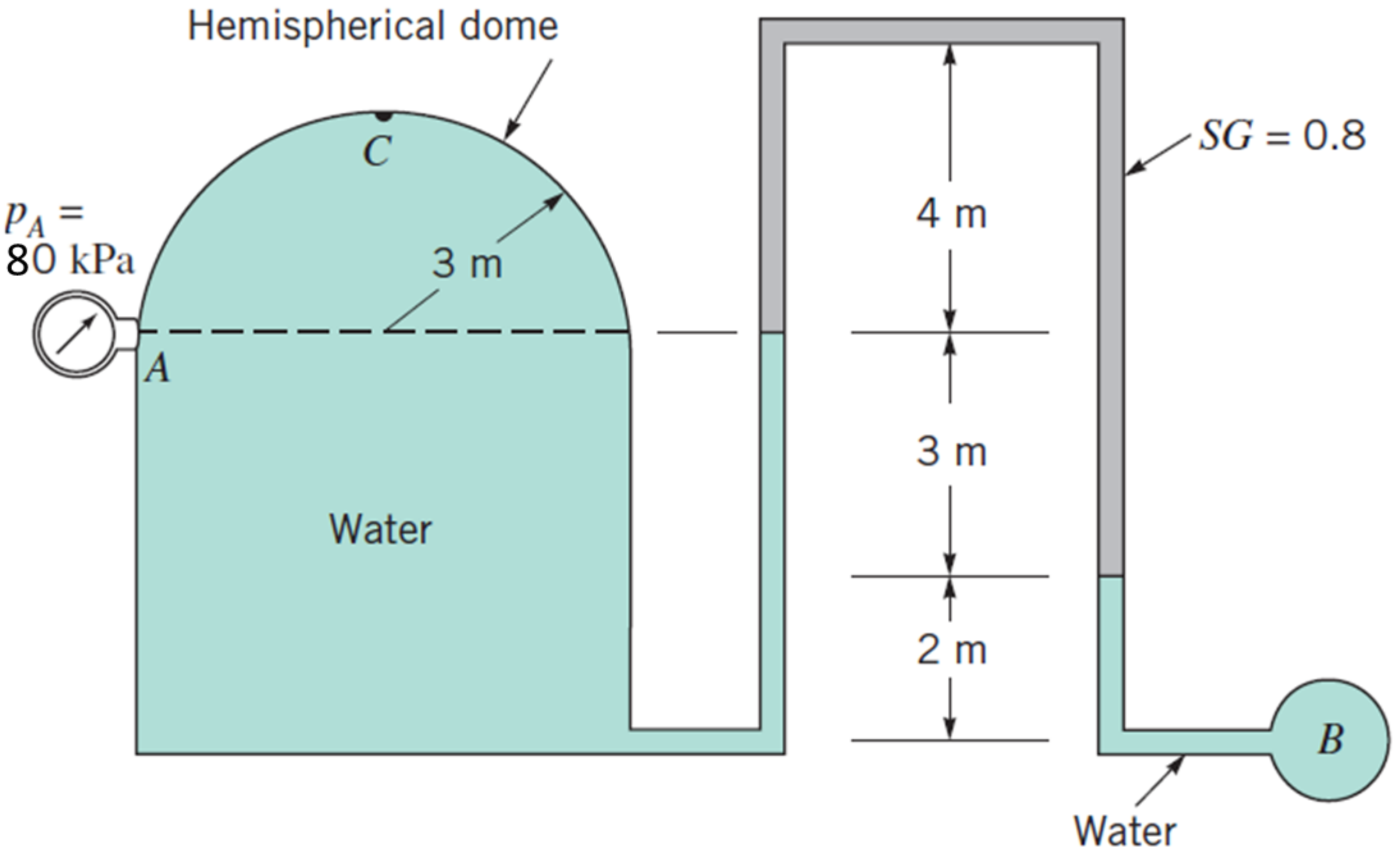
$$P_{air} + (SG_{oil}) \times \left(\gamma_{H_2O}\right) \times (h_1 + h_2) - \left(SG_{Hg}\right) \times \left(\gamma_{H_2O}\right) \times h_3 = 0$$

$$P_{air} = -(0.9) \times (9800\, N/m^3) \times \left(\frac{91.4 + 15.2}{100} m\right) + (13.6) \times (9800\, N/m^3) \times \left(\frac{22.9}{100} m\right) = 21kPa$$

$$P_{gage} = \frac{21kPa}{10^4\, cm^2/m^2} = 2.1\, N/cm^2$$

2-20: A closed cylindrical tank filled with water has a hemispherical dome and is connected to an inverted piping system as shown. The liquid in the top part of the piping system has a specific gravity of 0.8, and the remaining parts of the system are filled with water. If the pressure gage reading at *A* is 80 kPa, determine

a) the pressure in pipe *B* and
b) the pressure head, in millimeters of mercury, at the top of the dome (point *C*).



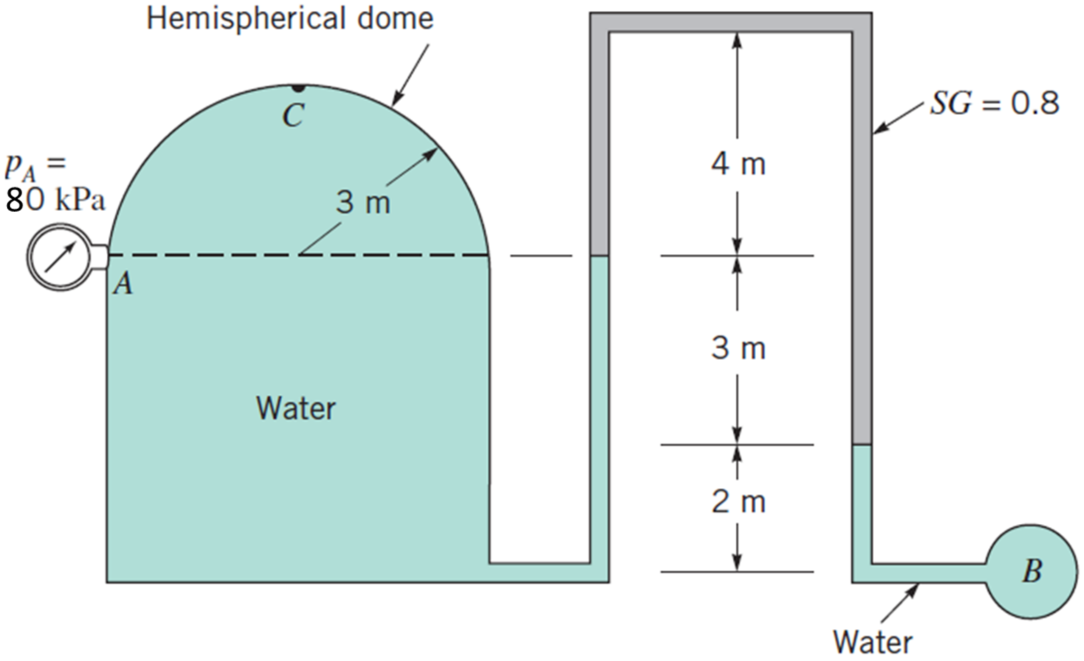
a) $P_A + (SG) \times (\gamma_{H_2O}) \times (3\ m) + \gamma_{H_2O} \times (2\ m) = P_B$

$= 80\ kPa + (0.8) \times (9.81 \times 10^3\ N/m^3) \times (3\ m) + (9.81 \times 10^3\ N/m^3) \times (2\ m)$

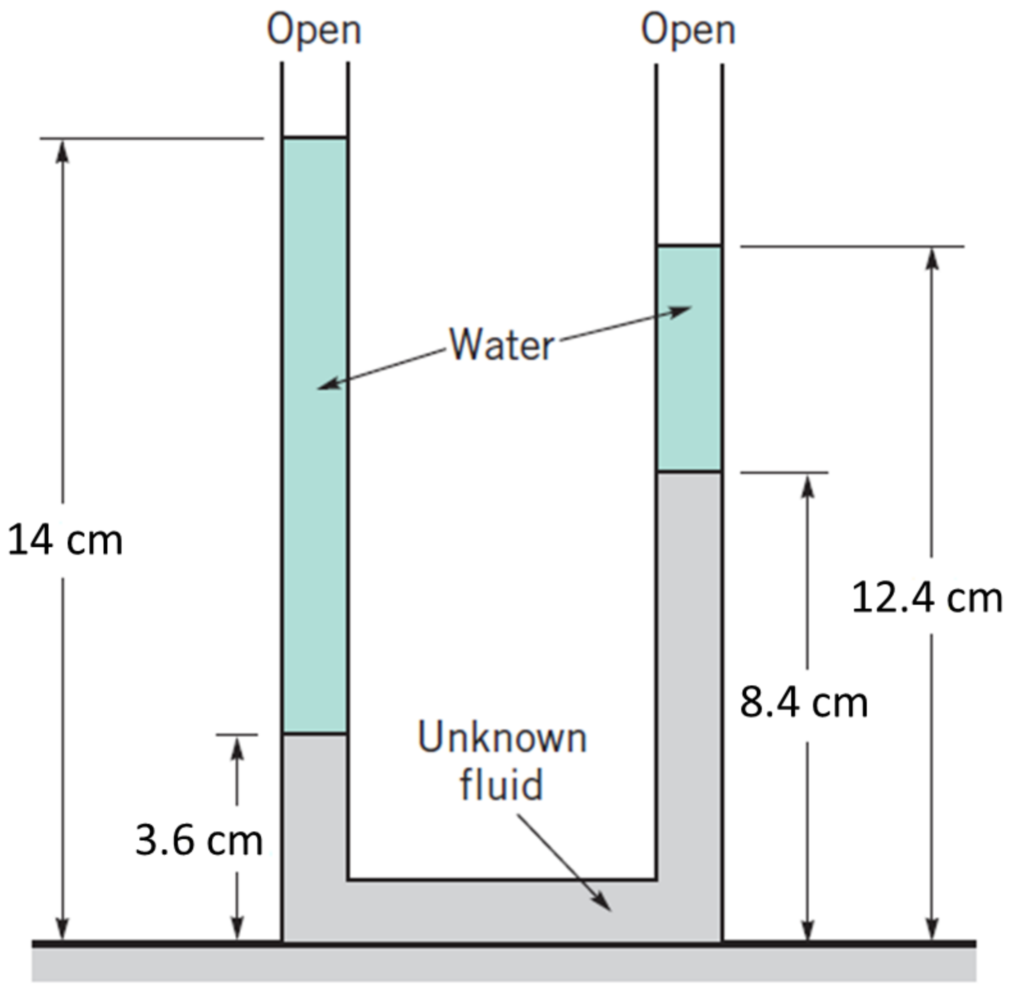
$= 123.12\ kPa$

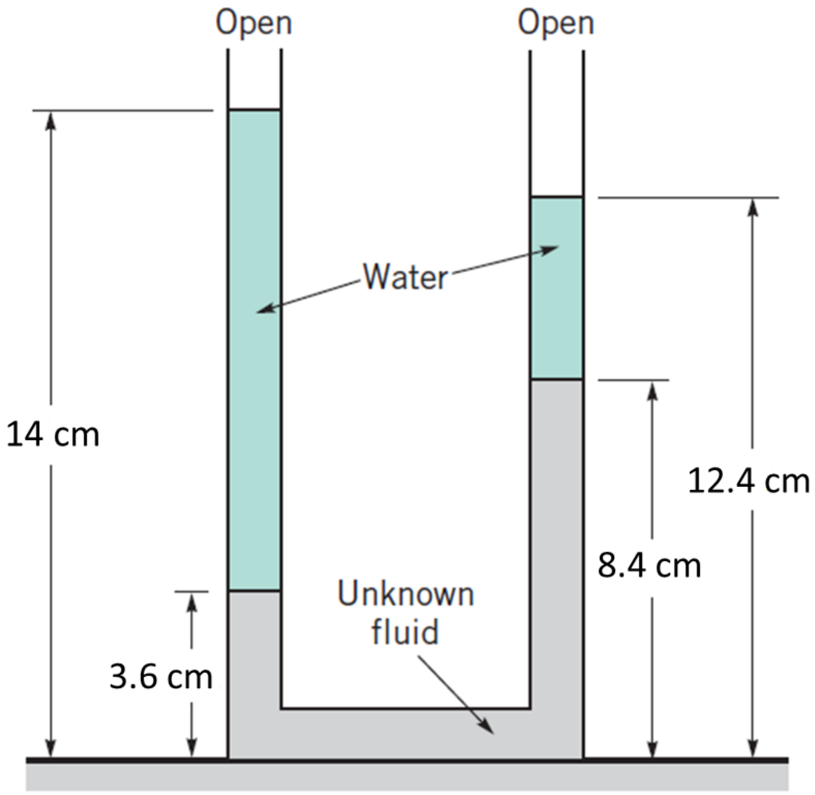
b) $P_C = P_A - \gamma_{H_2O} \times (3\ m) = 80\ kPa - (9.8 \times 10^3\ N/m^3) \times (3\ m) = 50.6 \times 10^3\ N/m^2$

$$h = \frac{P_C}{\gamma_{Hg}} = \frac{50.6 \times 10^3\ N/m^2}{133 \times 10^3\ N/m^3} = 0.38\ m = 380\ mmHg$$



2-24: For the configuration shown in the figure, what must be the value of the specific weight of the unknown fluid?

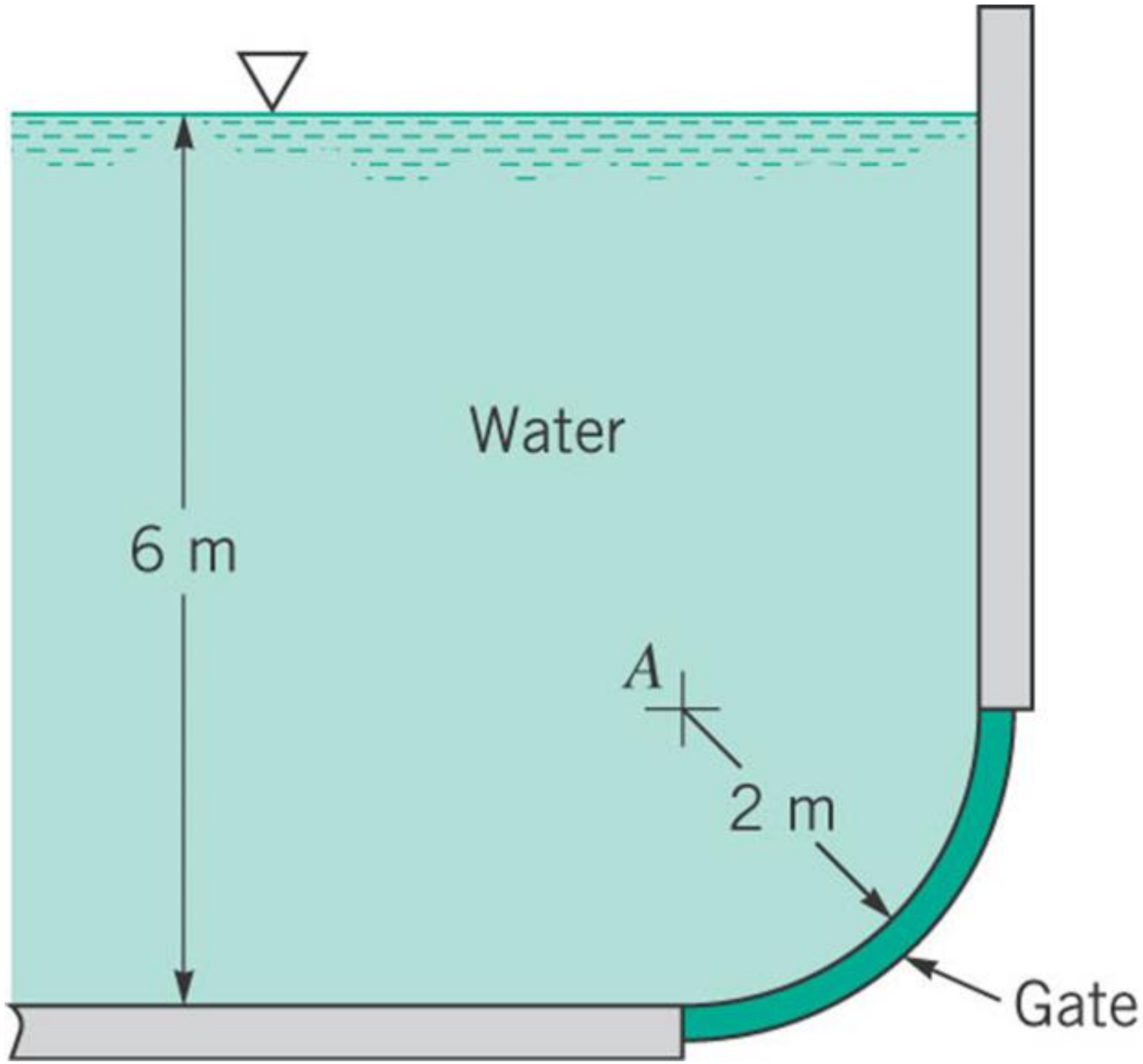


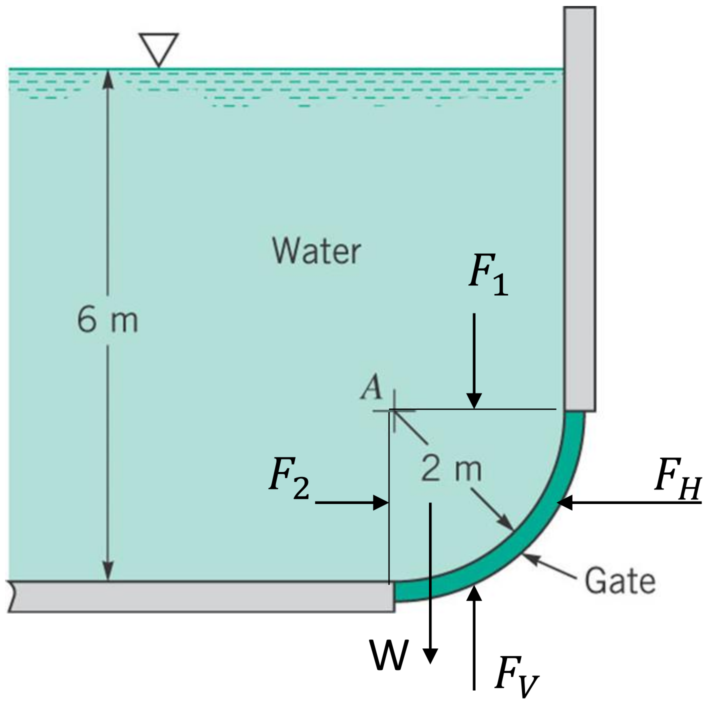


$$\gamma_{H_2O} \times \left(\frac{14-3.6}{100} m\right) - \gamma \times \left(\frac{8.4-3.6}{100} m\right) - \gamma_{H_2O} \times \left(\frac{12.4-8.4}{100} m\right) = 0$$

$$\gamma = \frac{\gamma_{H_2O} \times (14-3.6)\, m - (12.4-8.4)\, m}{(8.4-3.6)\, m} = (999.6\, kg/m^3) \times (9.81\, m/s^2) \times (\frac{10.4-4}{4.8} m) = 13074.77\, N/m^3$$

2-62: A 3-m-long curved gate is located in the side of a reservoir containing water as shown in the figure. Determine the magnitude of the horizontal and vertical components of the force of the water on the gate.





$$V = \frac{\pi \times (2)^2}{4} \times 3\,m = 3 \times \pi\,m^3$$

$$\Sigma F_x = 0$$

$$F_H = F_2 = \gamma \times h_C \times A = \gamma \times (4+1)\,m \times (2 \times 3)\,m$$

$$F_H = (9.8\,kN/m^3) \times (5\,m) \times (6\,m^2) = 294\,kN$$

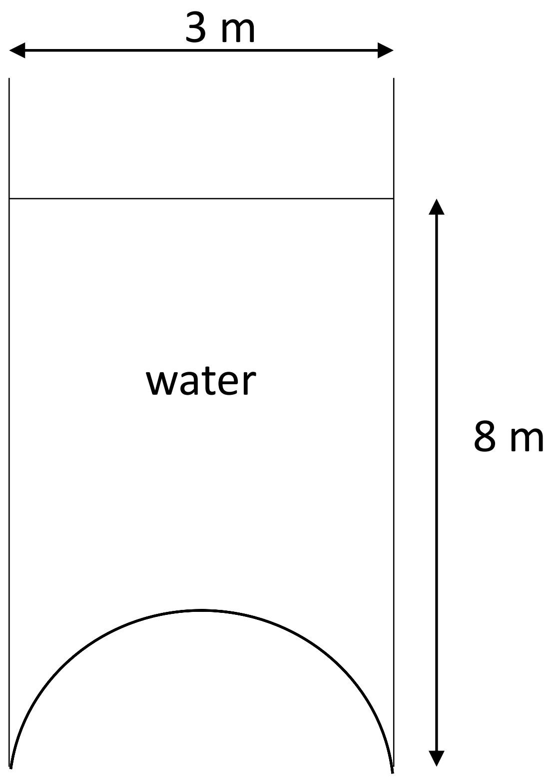
$$\Sigma F_y = 0 \qquad F_v = F_1 + W$$

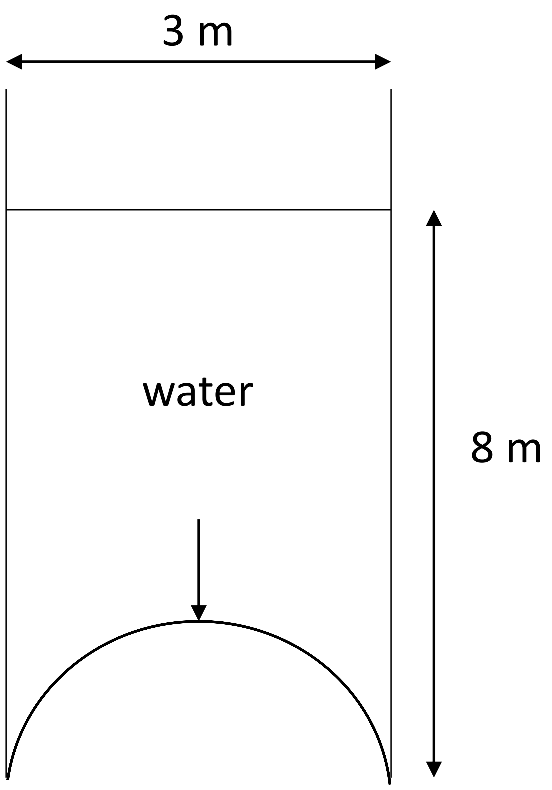
$$F_1 = [\gamma \times 4\,m] \times (2\,m \times 3\,m) = (9.8\ \,kN/m^3) \times (4\,m) \times (6\,m^2)$$

$$W = \gamma \times V = (9.8\,kN/m^3) \times (3 \times \pi\,m^3)$$

$$F_v = (9.8\,kN/m^3) \times (24\,m^3 + 3 \times \pi\,m^3) = 328\,kN$$

2-63: A 3 m diameter open cylindrical tank contains water and has a hemispherical bottom. Determine the magnitude, line of action, and direction of the force of the water on the curved bottom.





F = weight of the water supported by hemispherical bottom

$$= \gamma_{H_2O}\left(V_{cylinder} - V_{hemisphere}\right)$$

$$9.8\,kN/m^3 \times \left[\frac{\pi}{4} \times (3\,m)^2 \times (8\,m) - \underbrace{\frac{\pi}{12} \times (3\,m)^3}_{\frac{\frac{4}{3}\times \pi \times r^3}{2}}\right] = 485\,kN$$

The force is directed vertically downward.