2.99

2.99 An open tank has a vertical partition and on one side contains gasoline with a density $\rho = 700\ kg/m^3$ at a depth of 4 m, as shown in Fig. P2.99. A rectangular gate that is 4 m high and 2 m wide and hinged at one end is located in the partition. Water is slowly added to the empty side of the tank. At what depth, h, will the gate start to open?

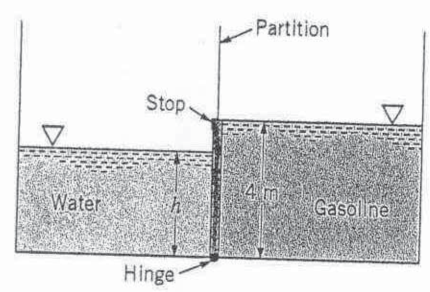
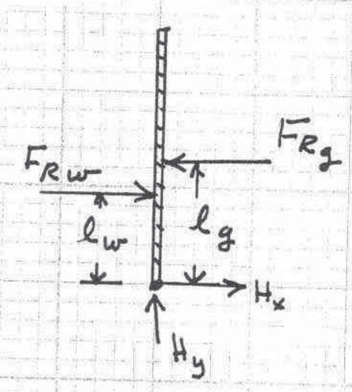


FIGURE P2.99



$F_{R_g} = \gamma_g\, h_{c_g}\, A_g$

where g refers to gasoline.

$F_{R_g} = \left(700\ \frac{kg}{m^3}\right)\left(9.81\ \frac{m}{s^2}\right)(2m)(4m \times 2m)$

$= 110 \times 10^3\ N = 110\ kN$

$F_{R_w} = \gamma_w\, h_{c_w}\, A_w$

where w refers to water.

$F_{R_w} = \left(9.80 \times 10^3\ \frac{N}{m^3}\right)\left(\frac{h}{2}\right)(2m \times h)$

where h is depth of water.

$F_{R_w} = (9.80 \times 10^3)\, h^2$

For equilibrium,

$\sum M_H = 0$

so that

$F_{R_w}\, \ell_w = F_{R_g}\, \ell_g$ with $\ell_w = \frac{h}{3}$ and $\ell_g = \frac{4}{3}\ m$

Thus, $(9.80 \times 10^3)(h^2)\left(\frac{h}{3}\right) = (110 \times 10^3\ N)\left(\frac{4}{3}\ m\right)$

and $h = \underline{\underline{3.55\ m}}$

which is the limiting value for h.