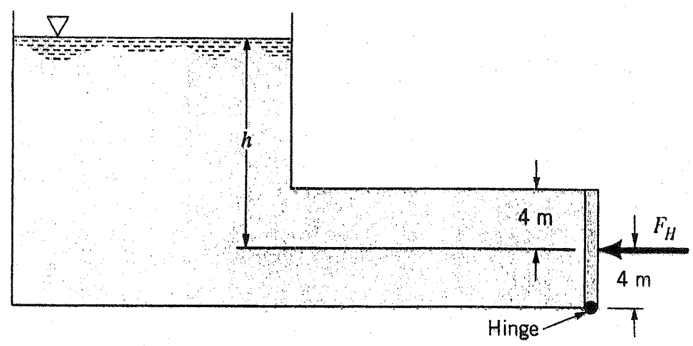
2.57

2.57 A 3-m-wide, 8-m-high rectangular gate is located at the end of a rectangular passage that is connected to a large open tank filled with water as shown in Fig. P2.57. The gate is hinged at its bottom and held closed by a horizontal force, F_H, located at the center of the gate. The maximum value for F_H is 3500 kN. **(a)** Determine the maximum water depth, h, above the center of the gate that can exist without the gate opening. **(b)** Is the answer the same if the gate is hinged at the top? Explain your answer.



■ FIGURE P2.57

For gate hinged at <u>bottom</u>

$$\sum M_H = 0$$

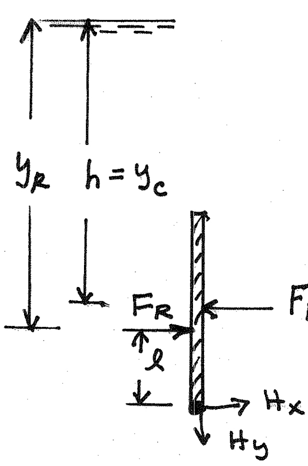
so that

$$(4\,m)\,F_H = \ell\,F_R \quad \text{(see figure)} \quad (1)$$

and

$$F_R = \gamma h_c A = \left(9.80\,\frac{kN}{m^3}\right)(h)(3\,m \times 8\,m)$$

$$= (9.80 \times 24\,h)\,kN$$



$$\ell = h + 4 - y_R$$

$$y_R = \frac{I_{xc}}{y_c A} + y_c = \frac{\frac{1}{12}(3\,m)(8\,m)^3}{h\,(3\,m \times 8\,m)} + h$$

$$= \frac{5.33}{h} + h$$

Thus,

$$\ell\,(m) = h + 4 - \left(\frac{5.33}{h} + h\right) = 4 - \frac{5.33}{h}$$

and from Eq. (1)

$$(4\,m)(3500\,kN) = \left(4 - \frac{5.33}{h}\right)(9.80 \times 24)(h)\,kN$$

so that

$$\underline{\underline{h = 16.2\,m}}$$

(con't)

2.57 (Con't)

For gate hinged at top

$$\sum M_H = 0$$

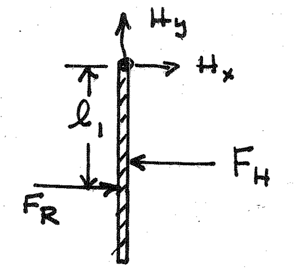
so that

$$(4\,m) F_H = \ell_1 F_R \quad \text{(see figure)} \qquad (1)$$

where

$$\ell_1 = y_R - (h-4) = \left(\frac{5.33}{h} + h\right) - (h-4)$$

$$= \frac{5.33}{h} + 4$$



$\ell_1 = y_R - (h-4)$

Thus, from Eq. (1)

$$(4\,m)(3500\,kN) = \left(\frac{5.33}{h} + 4\right)(9.80 \times 24)(h)\ kN$$

and

$$\underline{\underline{h = 13.5\,m}}$$

Maximum depth for gate hinged at top is less than maximum depth for gate hinged at bottom.