September 14, 2012

NAME

Fluids-ID

Quiz 3. The quarter circle gate BC in Figure 1 is hinged at C. Find the horizontal force P required to hold the gate stationary. The gate width into the paper is 3 m. Neglect the weight of the gate.

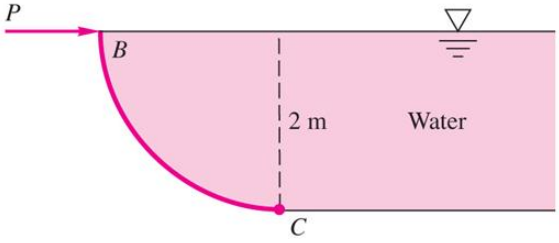
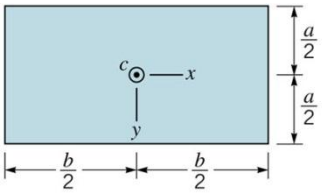


Figure 1

Resources:

- $F_H = \bar{p}A_{proj}$; $F_V = \gamma \forall$
- $y_{cp} = \bar{y} + I_{xc}/\bar{y}\,A_{proj}$; $x_{cp} = \bar{x}$ of $\forall$
- γ = 9,790 N/m^3 for water

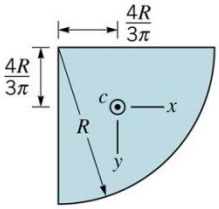


$A = ba$

$I_{xc} = \frac{1}{12}ba^3$

$I_{yc} = \frac{1}{12}ab^3$

$I_{xyc} = 0$



$A = \frac{\pi R^2}{4}$

$I_{xc} = I_{yc} = 0.05488R^4$

$I_{xyc} = -0.01647R^4$

Solution:

The horizontal component of water force is

$$F_H = \gamma h_c A_{proj} = \left(9790\frac{N}{m^3}\right)(1\ m)(2 \times 3\ m^2) = 58{,}740\ N$$

and the vertical component of water force is

$$F_V = \gamma \forall = \left(9790\frac{N}{m^3}\right)\left[\left(\frac{\pi}{4}\right)(2\ m)^2(3\ m)\right] = 92{,}270\ N$$ (+4 points)

The pressure center is

$$x_{cp} = \frac{4R}{3\pi} = \frac{(4)(2\ m)}{3\pi} = 0.849\ m$$

$$y_{cp} = \bar{y} + \frac{I_{xc}}{\bar{y}A_{proj}} = (1\ m) + \frac{(3\ m)(2\ m)^3/12}{(1\ m)(2\ m)(3\ m)} = 1.333\ m$$ (+4 points)

where x_{cp} is from the left of C and y_{cp} is down from the surface. Sum moments clockwise about point C:

$$\sum M_C = 0 = P \times (2m) - (58{,}740\ N)(2\ m - 1.333\ m) - (92{,}270\ N)(0.849\ m)$$

Solve for

$$P = 58{,}700\ N = \mathbf{58.7\ kN}$$ (+2 points)