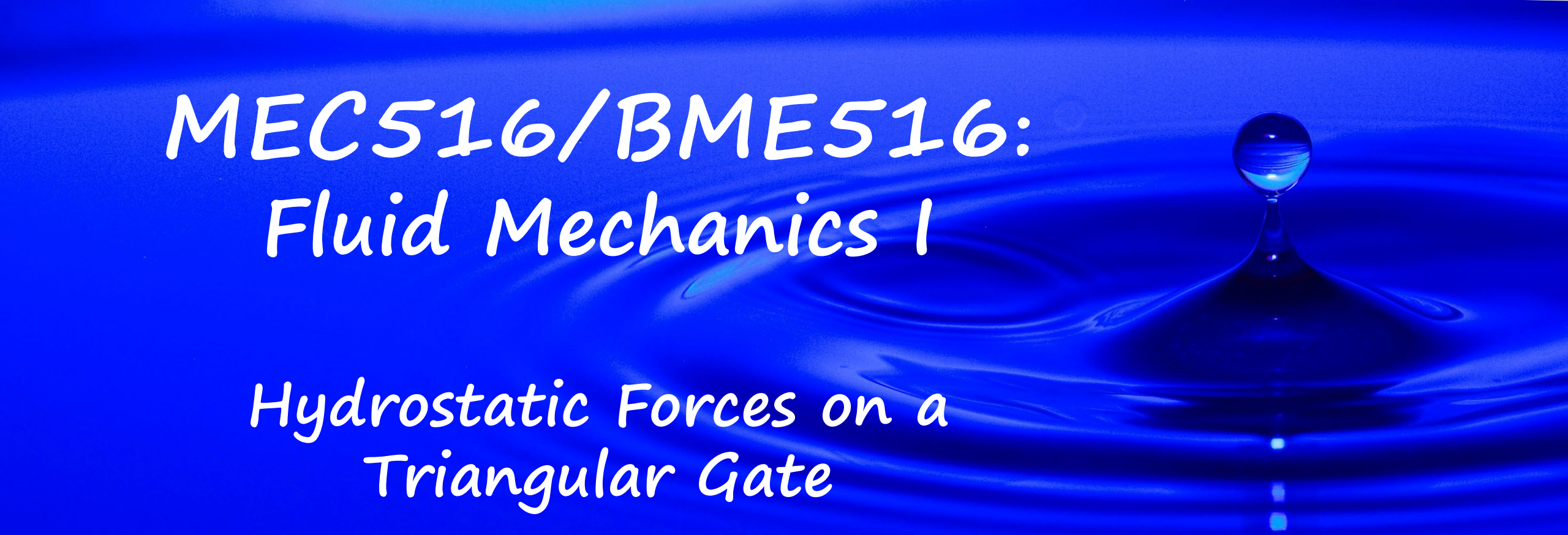
MEC516/BME516: Fluid Mechanics I

Hydrostatic Forces on a Triangular Gate

Solved Midterm Problem



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Midterm Exam Question

PDF available at
www.drdavidnaylor.net

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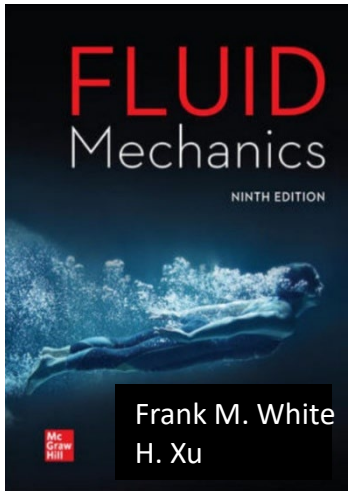
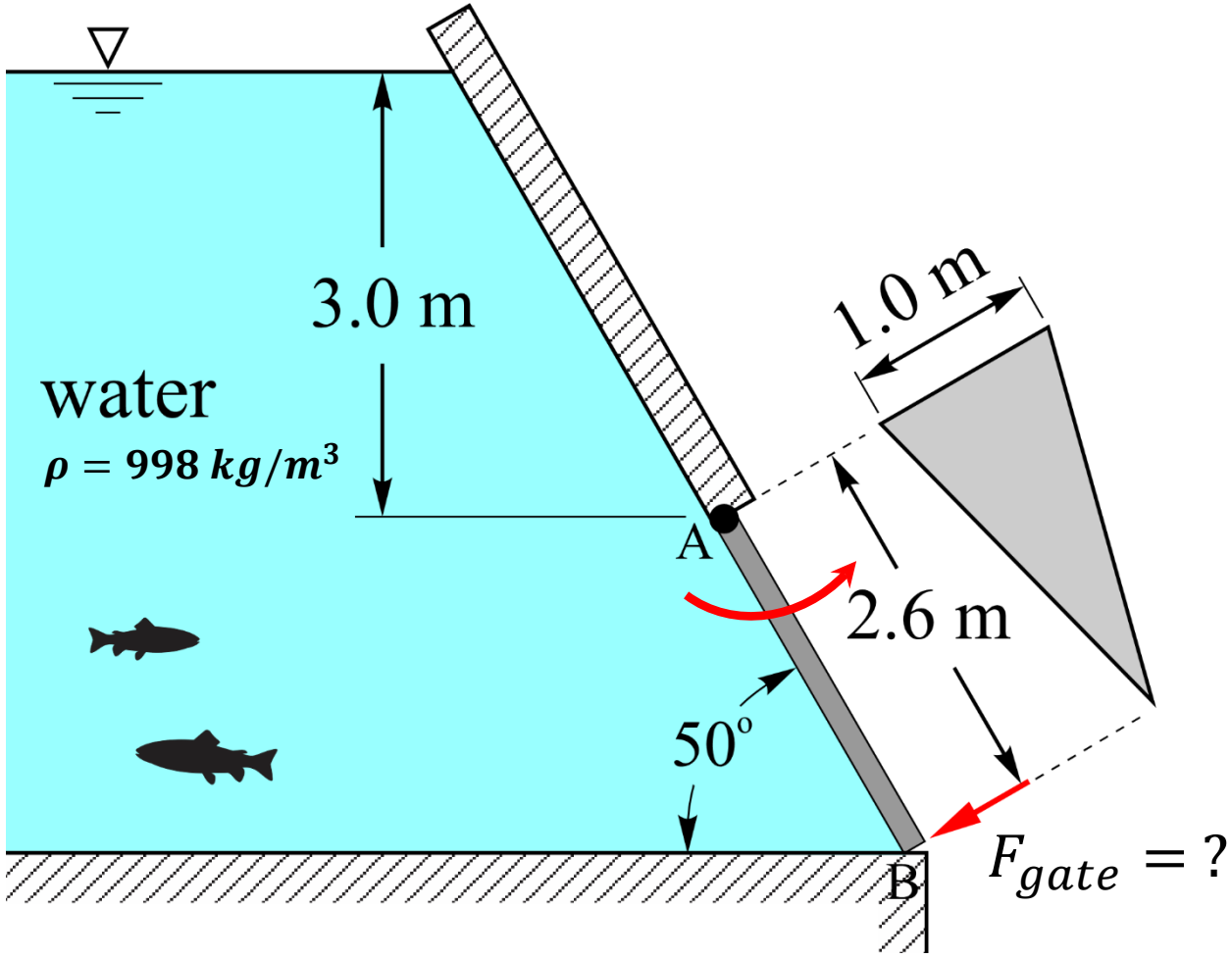
An isosceles triangular gate in a dam is inclined at 50^o from horizontal. The gate is $2.6\ m$ long, $1.0\ m$ wide and hinged at A, at a depth of $3.0\ m$. The gate weighs 1500 N. Calculate the magnitude of the force F_{gate} required to hold the gate closed.

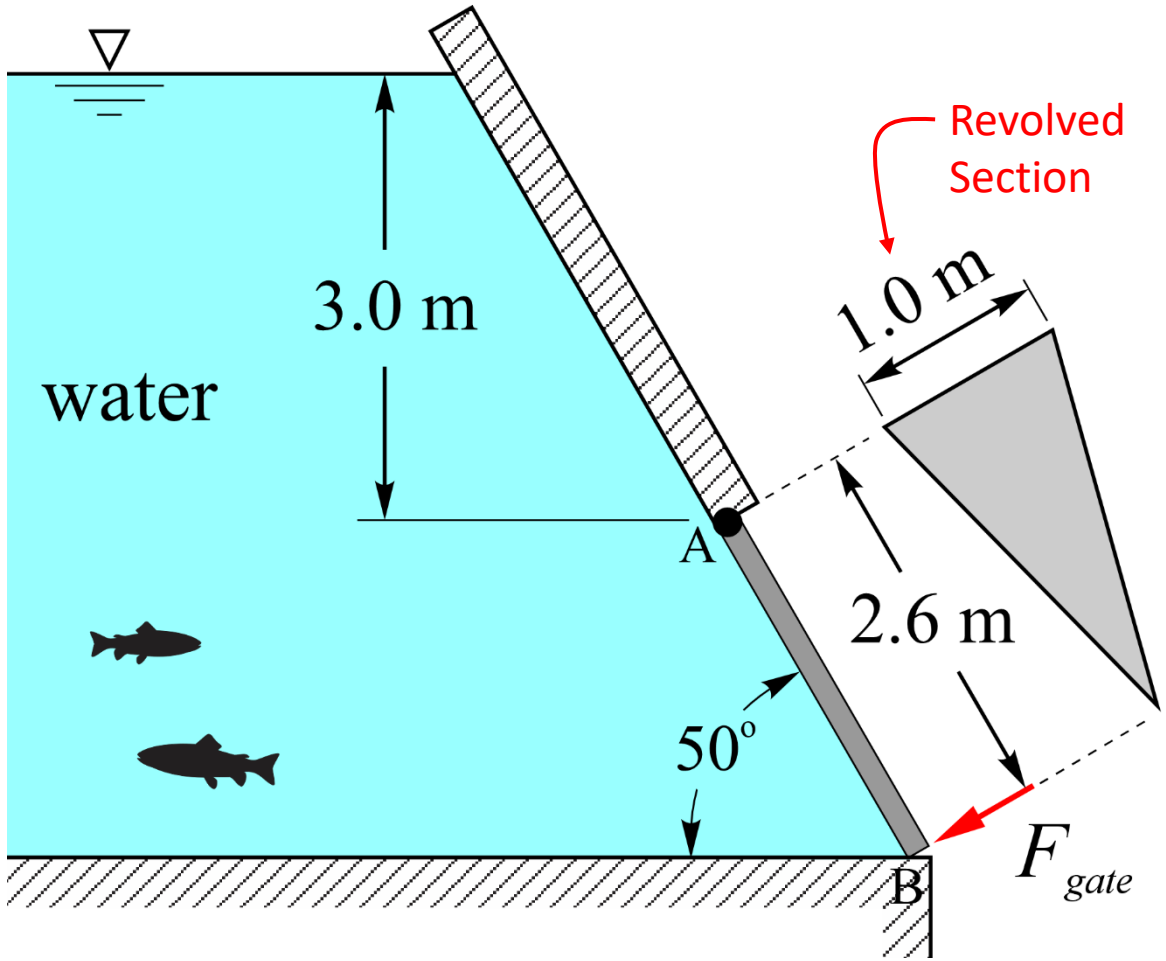


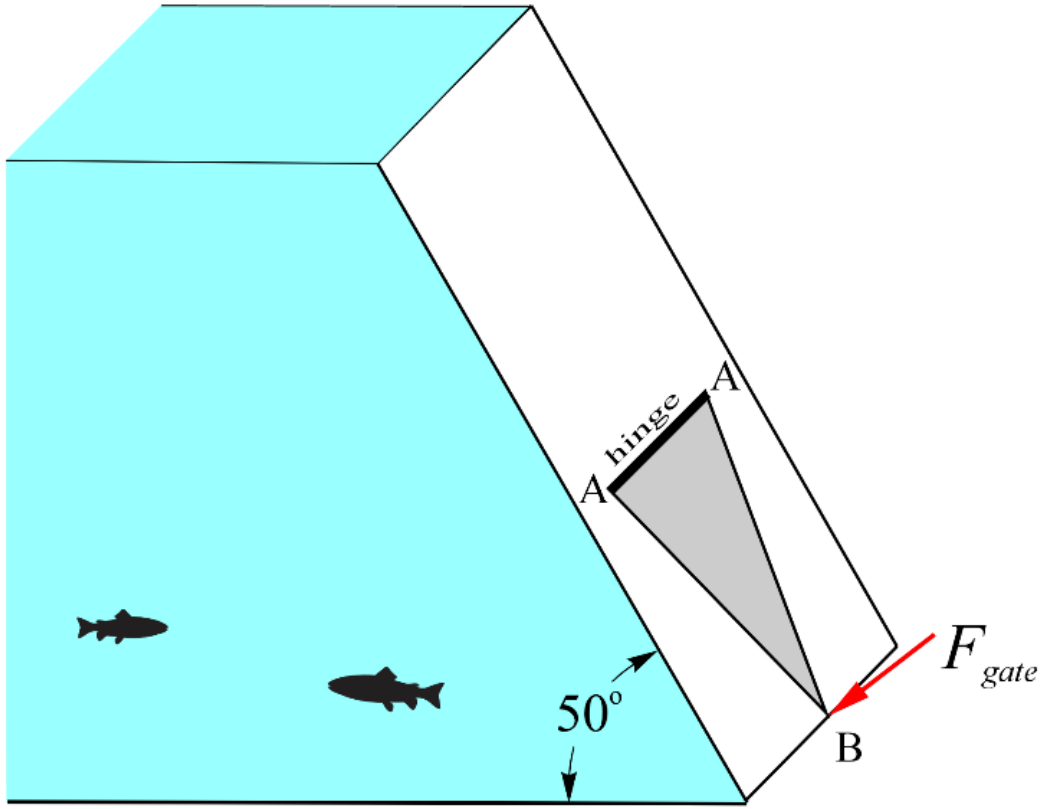
Link to "theory" for this problem in the description



Solution: Free body diagram

- Visualize the gate geometry

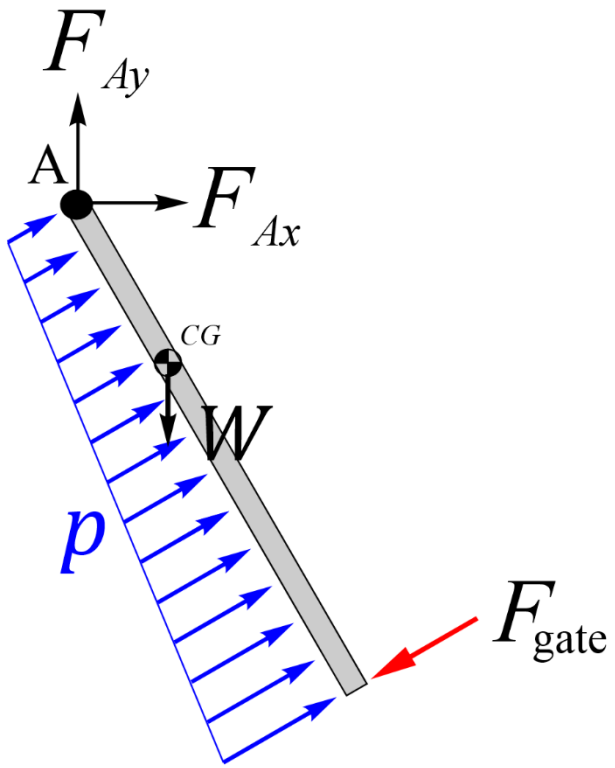


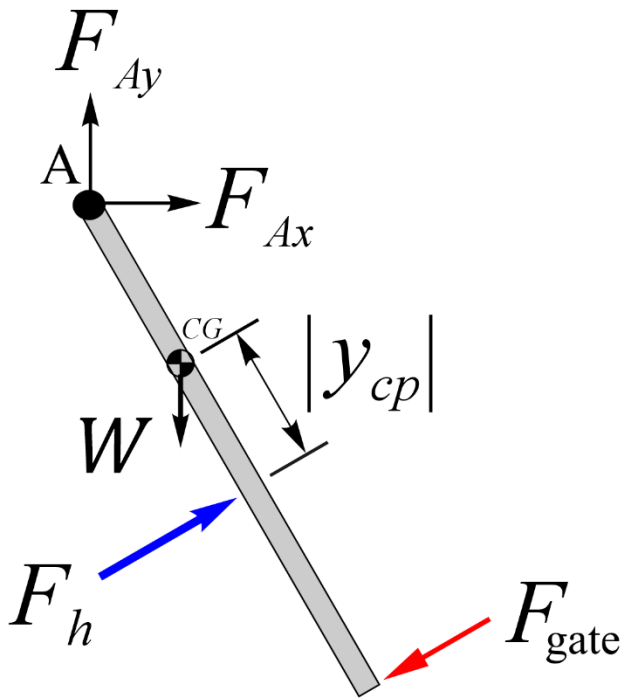


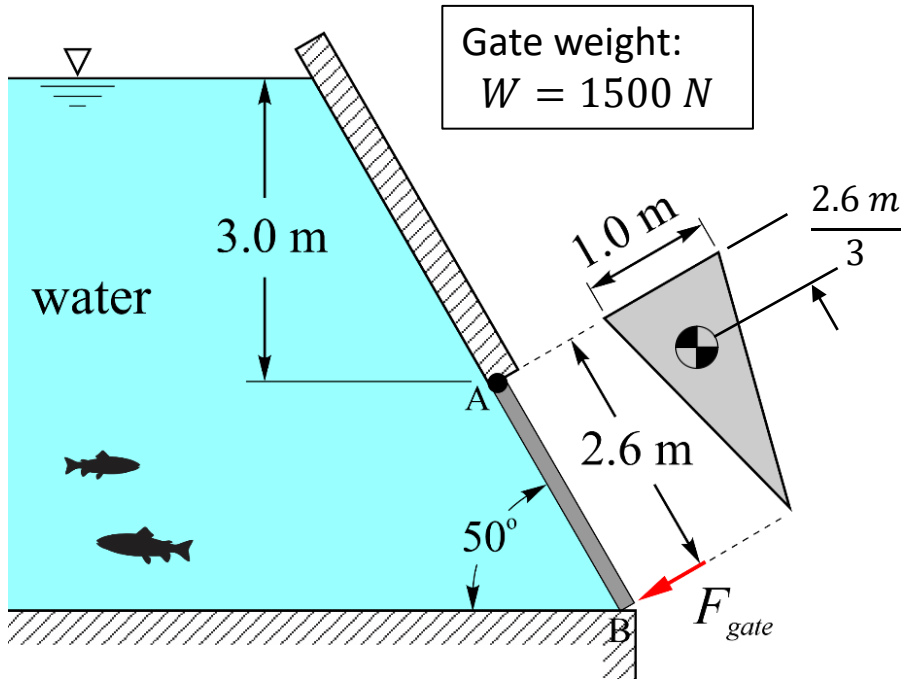
Oblique Projection

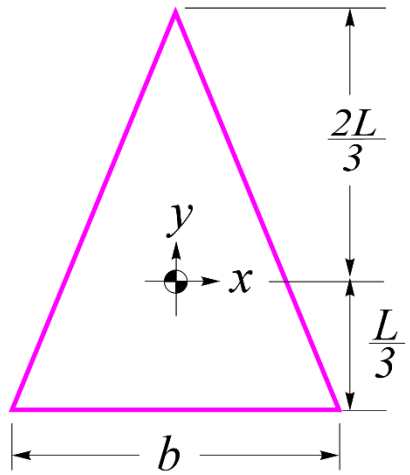
Solution: Free body diagram

- Static equilibrium, $\sum M_A = 0$









$$A = \frac{bL}{2}$$

$$I_{xx} = \frac{bL^3}{36}$$

Figure 2.13

Solution: Hydrostatic force, F_h

$$F_h = \gamma h_{CG} A = \rho g h_{CG} A$$

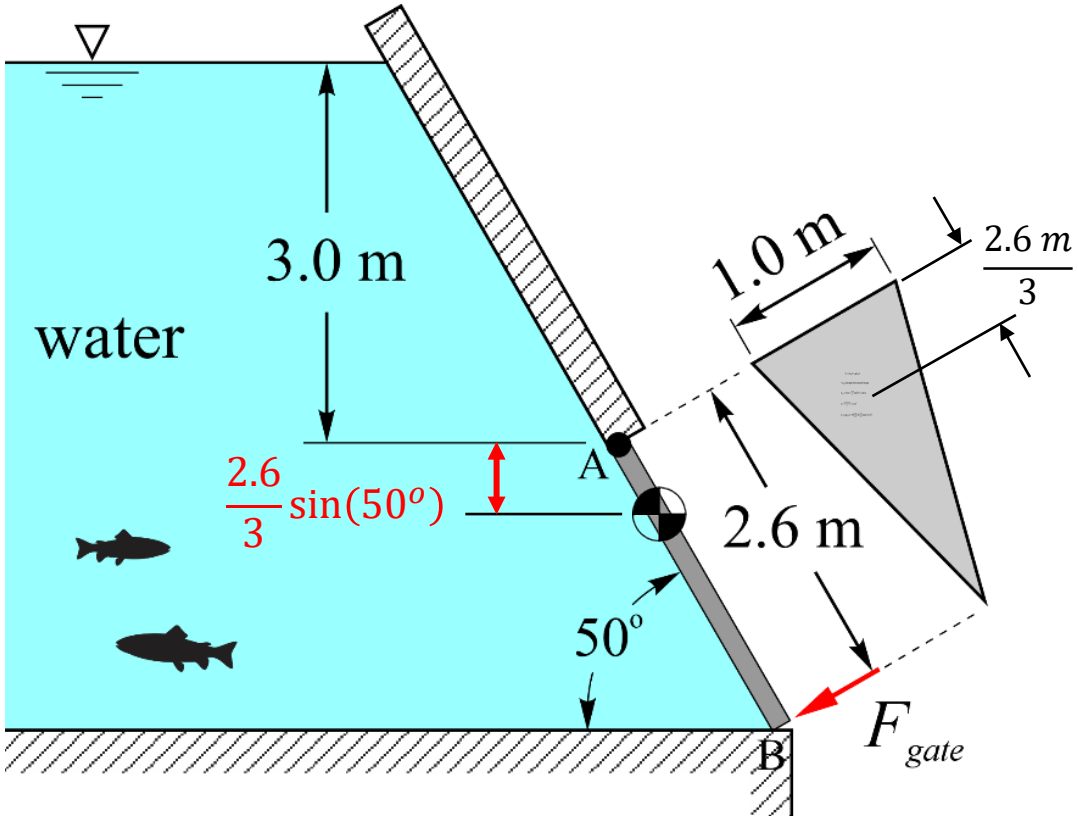
- h_{CG} is the depth of the centroid of the gate

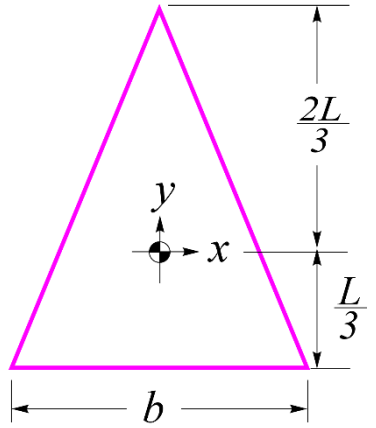
$$h_{CG} = 3.0\ m + \frac{2.6\ m}{3}\sin(50^o) = 3.66\ m$$

$$A = \frac{1.0\ m(2.6\ m)}{2} = 1.3\ m^2$$

$$F_h = \rho g h_{CG} A = 998\frac{kg}{\cancel{m^3}}\left(9.81\frac{m}{s^2}\right)3.66\cancel{m}\,(1.3\ \cancel{m^2}) = 46.63\ kN$$

$$kg\frac{m}{s^2} \equiv N$$





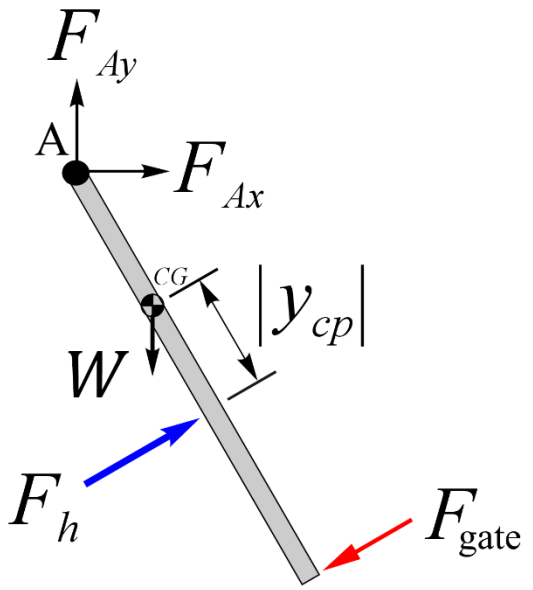
$$A = \frac{bL}{2}$$

$$I_{xx} = \frac{bL^3}{36}$$

Figure 2.13

Solution

$h_{CG} = 3.66\ m, A = 1.3\ m^2, F_h = 46.63\ kN$



- Location of the centre of pressure, y_{cp}

Angle from free surface, $\theta = 50^o$ *or* 130^o

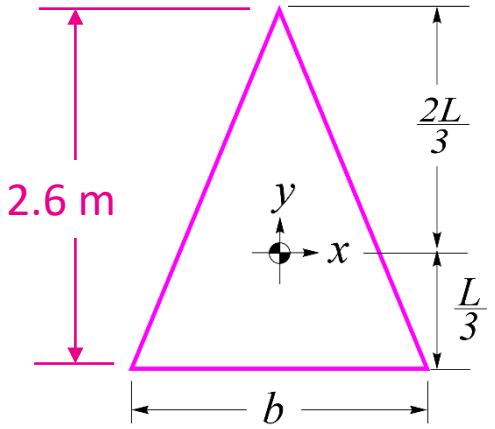
$$y_{cp} = -\frac{I_{xx}\sin(\theta)}{h_{CG}\,A}$$

Below centroid

- I_{xx} is the second moment of area about the centroid

$$I_{xx} = \frac{bL^3}{36} = \frac{1.0\ m(2.6\ m)^3}{36} = 0.4882\ m^4$$

$$y_{cp} = -\frac{I_{xx}\sin(\theta)}{h_{CG}\,A} = -\frac{0.4882\ m^4\ (\sin 130^o)}{3.66\ m\ (1.3\ m^2)} = -0.0785\ m$$

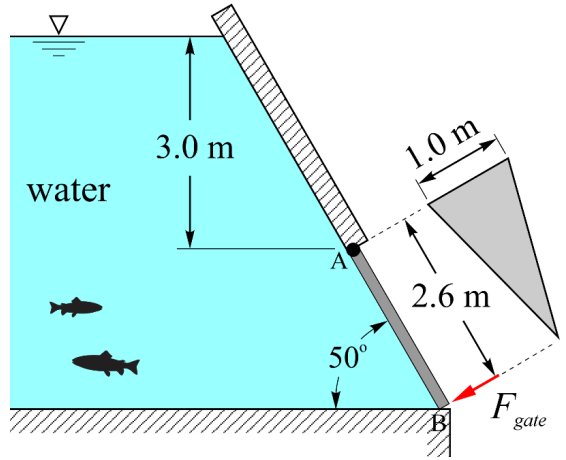


$$A = \frac{bL}{2}$$

$$I_{xx} = \frac{bL^3}{36}$$

Figure 2.13

Solution: $y_{cp} = -0.0785\ m,\ \ F_h = 46.63\ kN, W = 1500\ N$

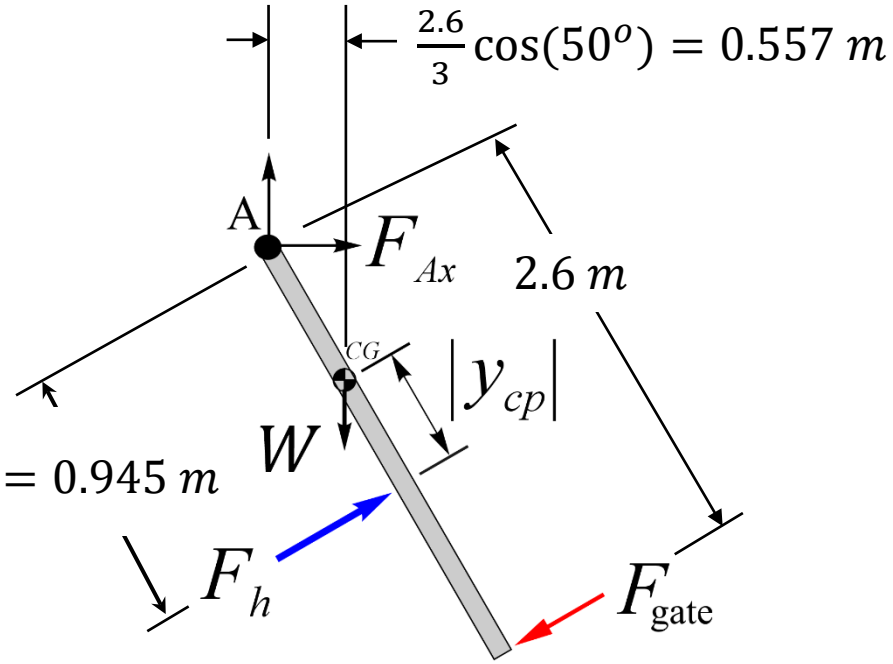


- Static Equilibrium, $\sum M_A = 0$ +

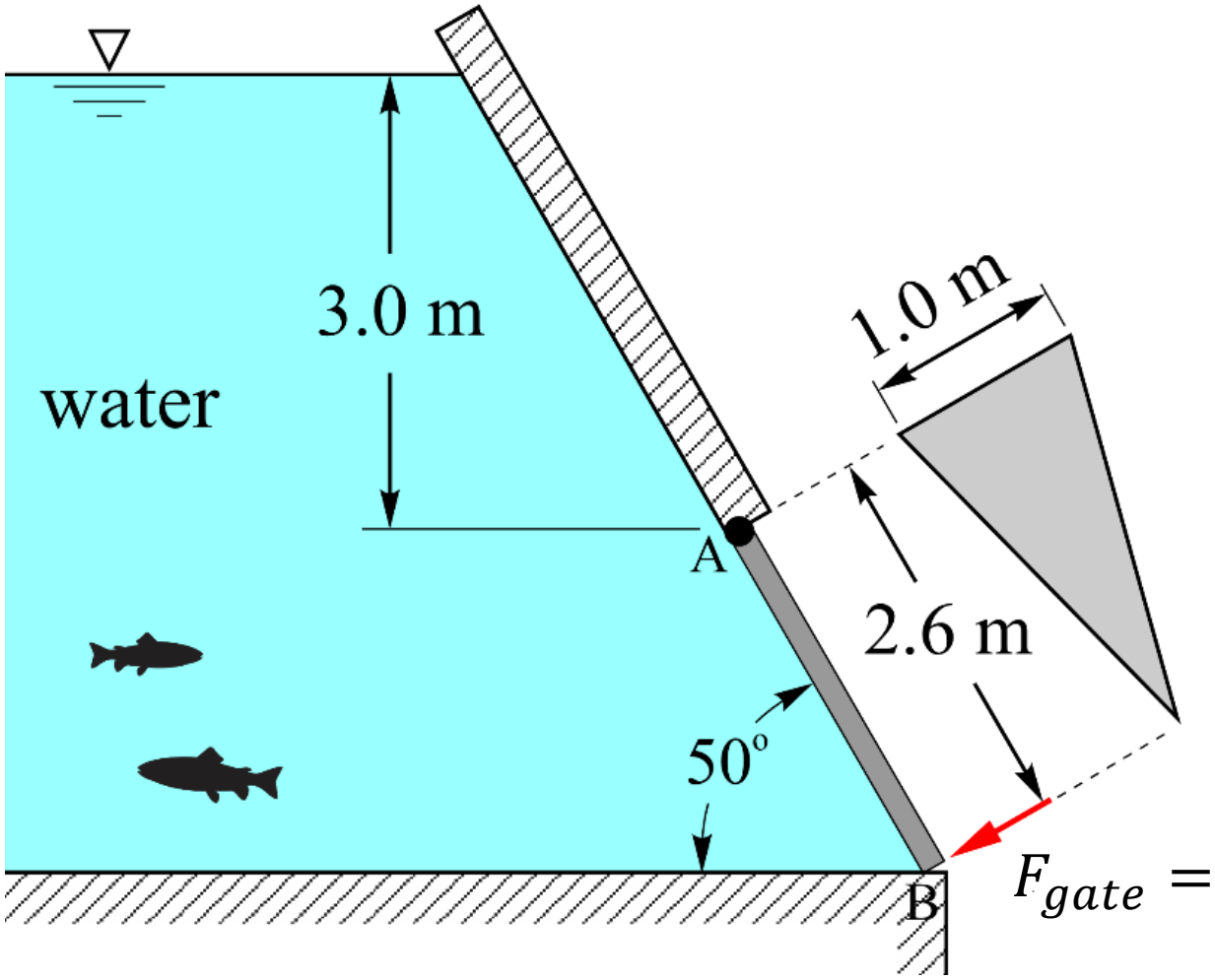
$$F_{gate}(2.6\ m) + W\ (0.557\ m) - F_h(0.945\ m) = 0$$

$$F_{gate} = \frac{-1500\ N\ (0.557\ m) + 46630\ N\ (0.945\ m)}{2.6\ m}$$

$$F_{gate} = 16.6\ kN$$ **Answer**



$$\frac{2.6}{3}m + 0.0785m = 0.945\ m$$



$F_{gate} = 16.6\ kN$

END NOTES

Prepared and delivered by Professor David Naylor

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