Exercise 6 Solutions

3.16

3.54

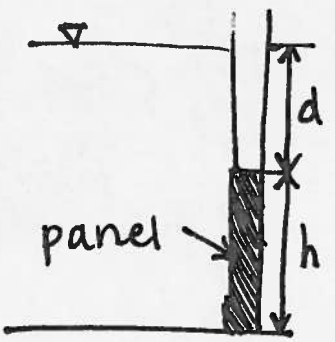
3.66

3.70) As shown, water (15°C) is in contact with a square panel; d = 1 m and h = 2m.

UNKNOWN:

a) calculate the depth of the centroid
b) calculate the resultant force on the panel
c) calculate the distance from the centroid to the CP.

SKETCH:



KNOWN:

$T = 15°C$

$\gamma = 9800\ N/m^3 \Rightarrow$ Table A.5.

GOVERNING EQNS:

$$F = \bar{p}A$$

$$y_{cp} - \bar{y} = \bar{I}/(\bar{y}A)$$

SOLUTION:

Depth of the centroid of area:

$$\bar{z} = d + h/2 = 1m + (2m)/2 \Rightarrow \boxed{\bar{z} = 2m}$$

Hydrostatic EQN:

$$\bar{p} = \gamma\bar{z} = 9800 N/m^3 (2m) = 19.6 kPa$$

Resultant force:

$$F = \bar{p}A = (19.6 kPa)(2m)(2m)$$

$$\boxed{F = 78.4\ kN}$$

3.70 continued)

Distance to CP

Find $\bar{I}$ using formula from Fig. A.1.

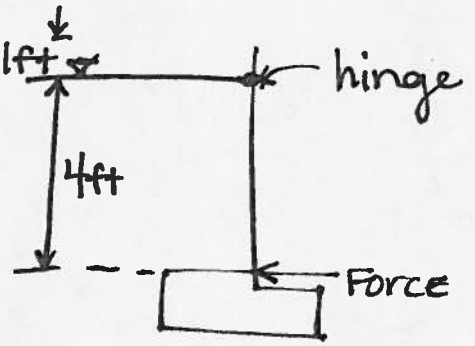
$$\bar{I} = \frac{bh^3}{12} = \frac{(2m)(2m)^3}{12} = 1.333 m^4$$

$$\bar{y} = \bar{z} = 2m$$

$$y_{cp} - \bar{y} = \frac{\bar{I}}{\bar{y}A} = \frac{(1.333\ m^4)}{(2m)(2m)^2}$$

$$\boxed{y_{cp} - \bar{y} = 0.167 m}$$

3.74) A rectangular gate is hinged at the water line, as shown. The gate is 4ft high and 8ft wide. The specific weight of water is 62.4 lb_f/ft^3. Find the necessary force (in lb_f) applied at the bottom of the gate to keep it closed.



UNKNOWN:

Force to keep gate closed.

KNOWN:

$\gamma_{water} = 62.4\ lb_f/ft^3$

Rectangular gate

$h = 4ft$

$b = 8ft$

SOLUTION:

Hydrostatic Force (magnitude):

$$F_G = \bar{P}A$$
$$= \gamma_{H_2O} \times \bar{y}(32ft^2)$$
$$= (62.4\ lb_f/ft^3)(2ft)(32ft^2) = 3993.6\ lb_f$$

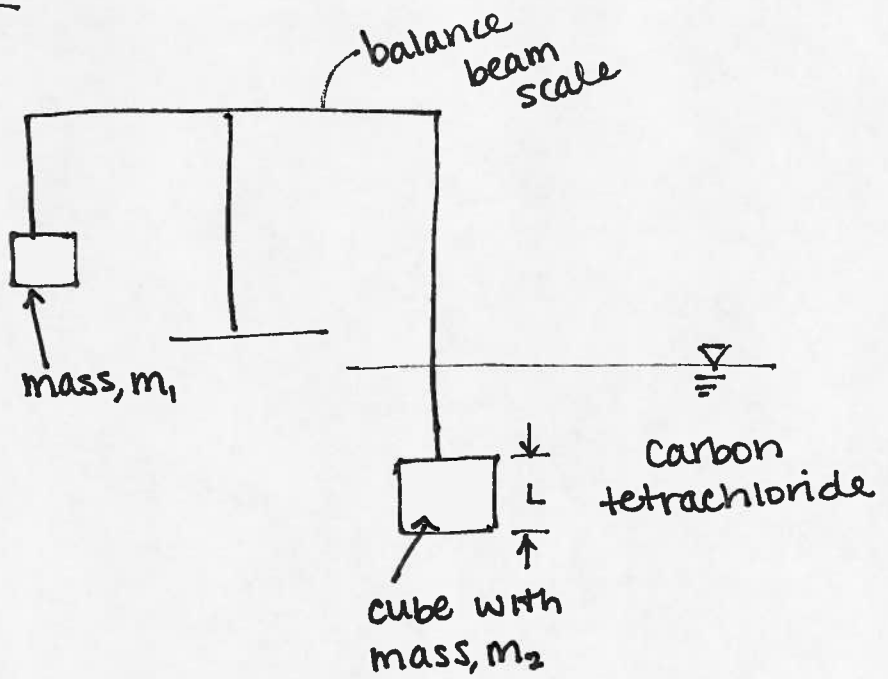
Center of pressure. Since gate extends from the free surface of the water, F_G acts at 2/3 below the water surface.

$$\Sigma M = 0$$
$$\left(F_G \times \frac{2}{3}(4ft)\right) - (4ft)F = 0$$
$$F = \frac{3993.6\ lb_f\ (2.67ft)}{4ft}$$

$$\boxed{F = 2662.4\ lb_f} \text{ to the left.}$$

3.101) As shown, a cube (L=60mm) suspended in carbon tetrachloride is exactly balanced by an object of mass $m_1 = 700g$. Find the mass m_2 of the cube.

SKETCH:



KNOWN:

$m_1 = 700g$

$L = 0.06m$

UNKNOWN:

$m_2 (kg) = ?$

$\gamma_{CT} = 15{,}600 N/m^3 \Rightarrow$ Table A.4

$T = 20°C$

SOLUTION:

Force on balance arm.

$$\left\{\begin{matrix}\text{Force on} \\ \text{balance arm}\end{matrix}\right\} = \left\{\begin{matrix}\text{weight of} \\ \text{block}\end{matrix}\right\} = mg = (0.7kg)\left(9.81\frac{m}{s^2}\right) = 6.867N$$

Equilibrium (applied to cube)

$$\left\{\begin{matrix}\text{Force on} \\ \text{balance arm}\end{matrix}\right\} + \left\{\begin{matrix}\text{Buoyant} \\ \text{Force on} \\ \text{cube}\end{matrix}\right\} = \left\{\begin{matrix}\text{weight of} \\ \text{cube}\end{matrix}\right\}$$

$$F + \gamma (L_2)^3 = m_2 g$$

3.101 continued)

Solve for m_2

$$m_2 = \frac{F + \gamma(L_2)^3}{g} = \frac{(6.867\,N) + (15,600\,N/m^3)(0.06m)^3}{9.81\,m/s^2}$$

$$\boxed{m_2 = 1.04\,kg}$$