TUTORIAL #2

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Question #1

1. The cross section of a fresh-water tank with a slanted bottom is shown in Figure 1. A rectangular door 1.6 m by 0.8 m (normal to the plane of the figure) in the bottom of the tank is hinged at *A* and is opened against the pressure of the water by the cable under a tension *P*. Calculate *P*. The specific weight of water is 10 kN/m³.

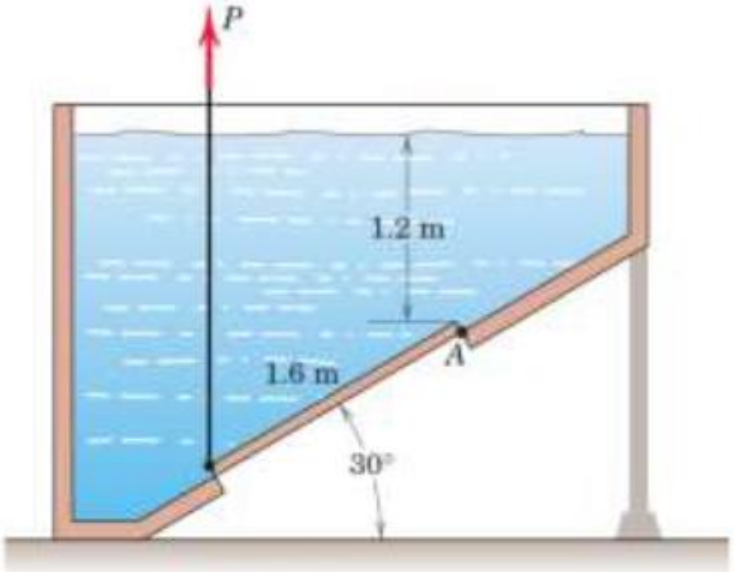


Fig. 1

Solution # 1

Given values:-

$\gamma_W = 10\, kN/m^3\,, h_1 = 1.2\, m, h_2 = 1.2 + (1.6 \times \sin 30°) = 2\, m$

Water pressure at the door can be given as

Pressure P_1:-

$P_1 = \gamma_W h_1 = 10 \times 1.2 = 12\, kPa$

Pressure P_2:-

$P_2 = \gamma_W h_2 = 10 \times 2 = 20\, kPa$

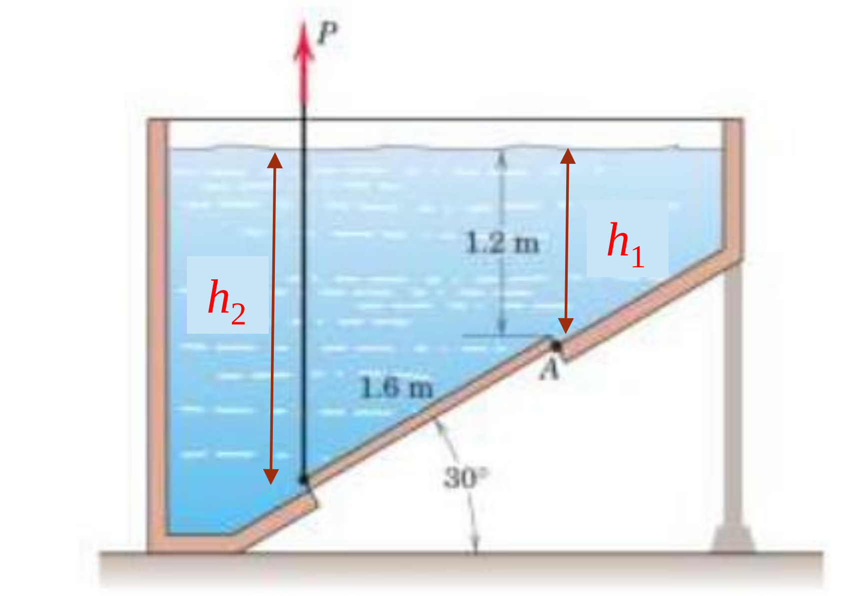


Fig. 1

Solution # 1

Force due to water on gate

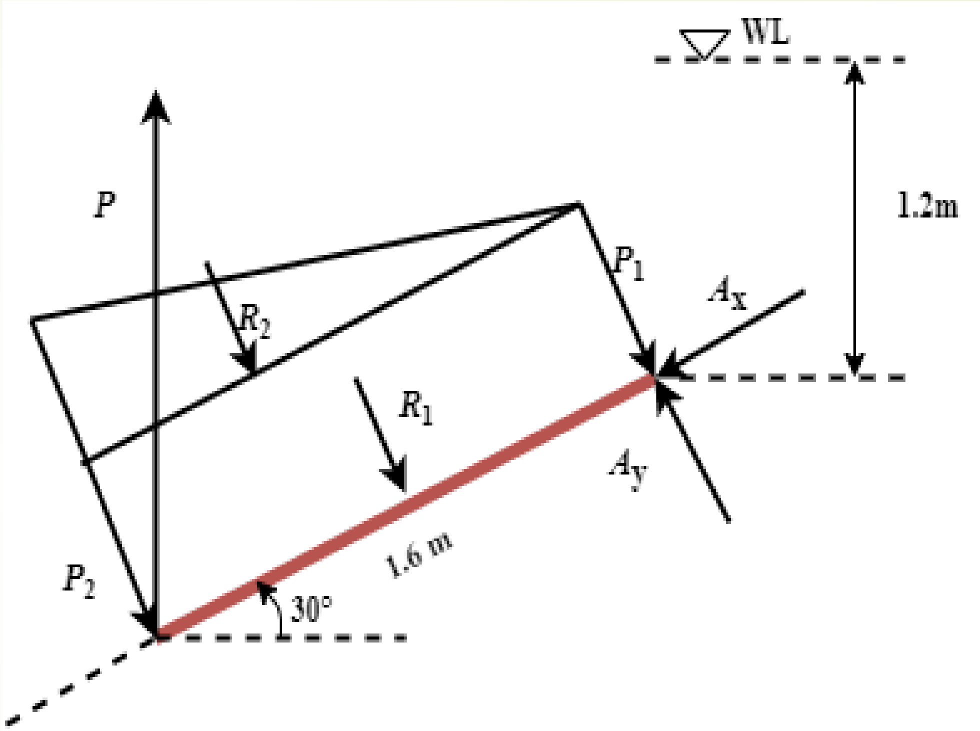
Force R_1:-

$$R_1 = pressure \times area = P_1 \times A$$

$$R_1 = 12 \times 1.6 \times 0.8 = 15.36\ kN$$

Force R_2:-

$$R_2 = (20 - 12) \times \frac{1}{2} \times 1.6 \times 0.8 = 5.12\ kN$$



Solution # 1

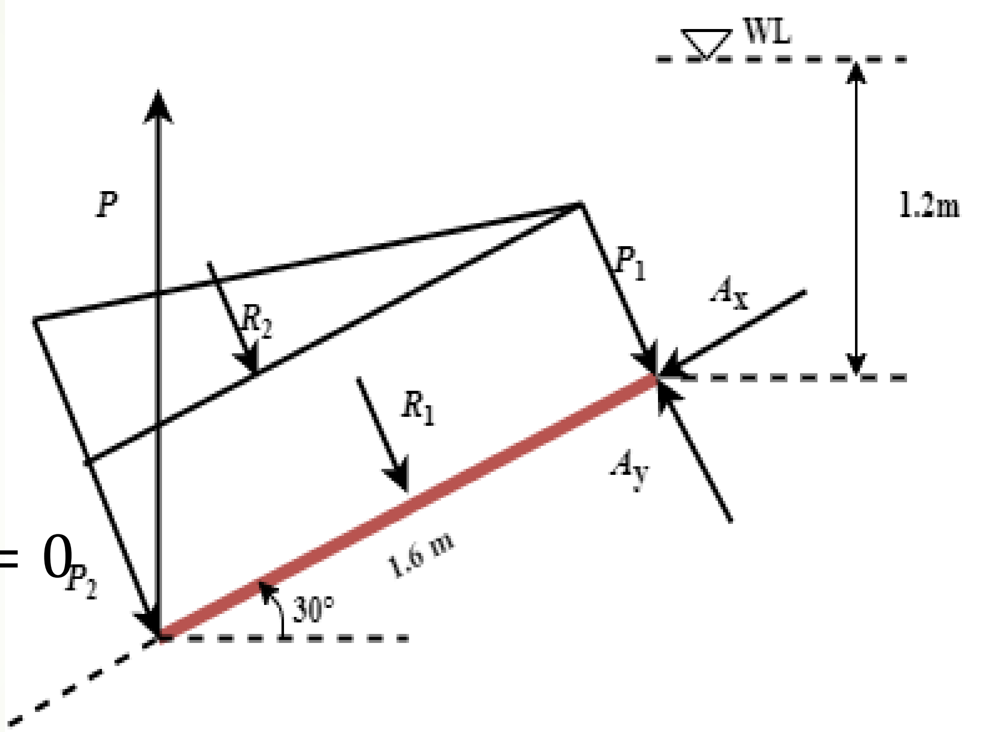
Tension in cable P :-

$$\sum M_A = 0$$

$$P \times (1.6\cos 30°) - R_1 \times \frac{1}{2} \times 1.6 - R_2 \times \frac{2}{3} \times 1.6 = 0$$

$$P \times (1.6\cos 30°) - 15.36 \times \frac{1}{2} \times 1.6 - 5.12 \times \frac{2}{3} \times 1.6 = 0$$

$$\boxed{P = 12.81\ kN}$$



Question #2

2. A freshwater marsh is drained to the ocean through an automatic tide gate that is 4 m wide and 3 m high. The gate is held by hinges located along its top edge at A and bears on a sill at B. If the water level in the marsh is $h = 6$ m, determine the ocean level d for which the gate will open. (Specific weight of salt water = 10.05 kN/m^3.)

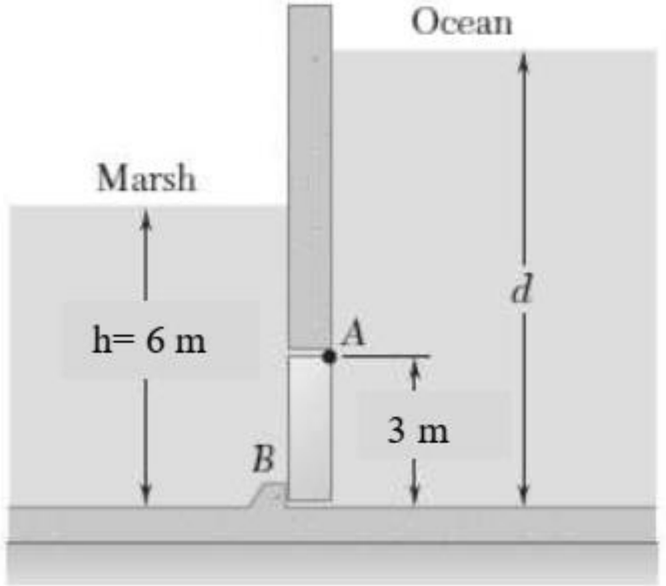


Fig. 2

Solution # 2

Specific weight of freshwater $\gamma_{fw} = 9.81\ kN/m^3$

Specific weight of saltwater $\gamma_{sw} = 10.05\ kN/m^3$

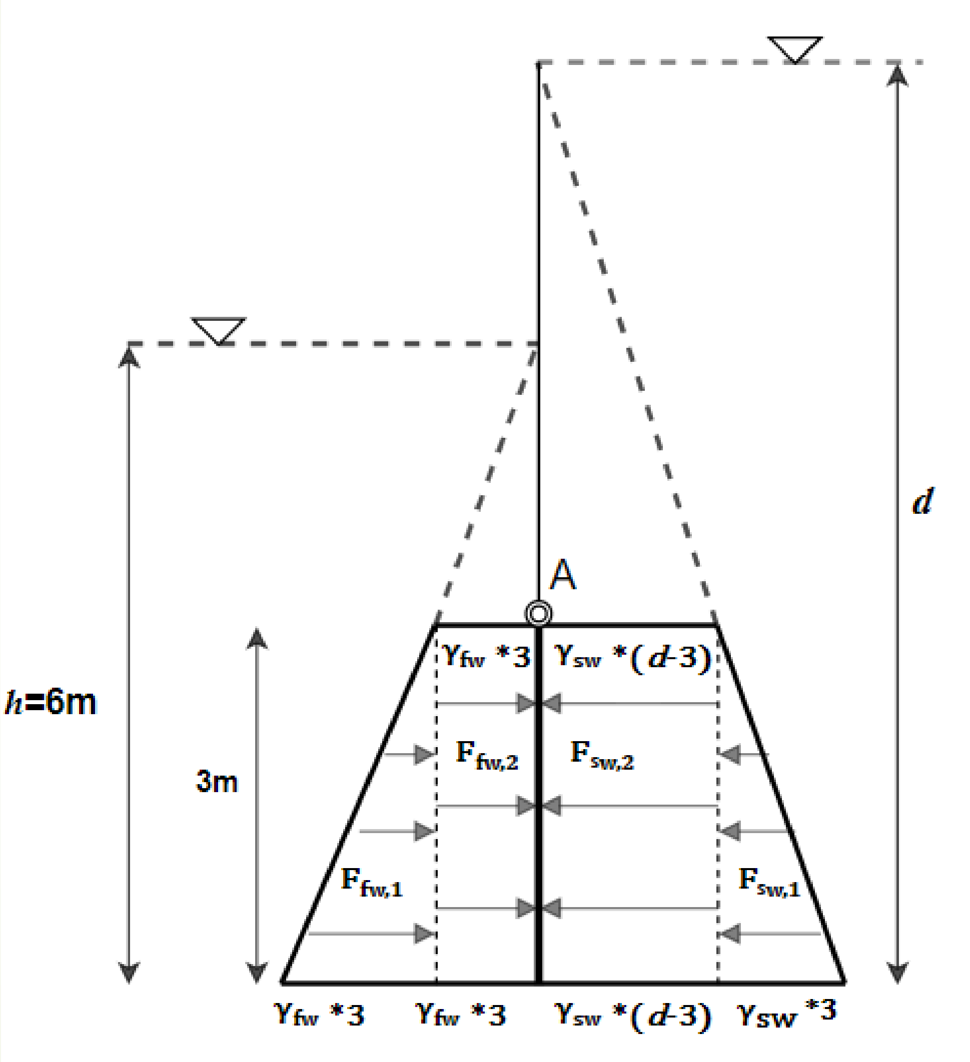
Force acting on gate due to fresh water will be

$$F_{fw,1} = \frac{1}{2} \times \gamma_{fw} \times 3 \times 3 \times 4 = 176.58\ kN$$

$$F_{fw,2} = \gamma_{fw} \times 3 \times 3 \times 4 = 353.16\ kN$$

Moment at hinge A due to force of freshwater-

$$M_{fw,A} = F_{fw,1} \times \frac{2}{3} \times 3 + F_{fw,2} \times \frac{1}{2} \times 3 = 882.9\ kNm$$



Solution # 2

Force acting on gate due to salt water will be-

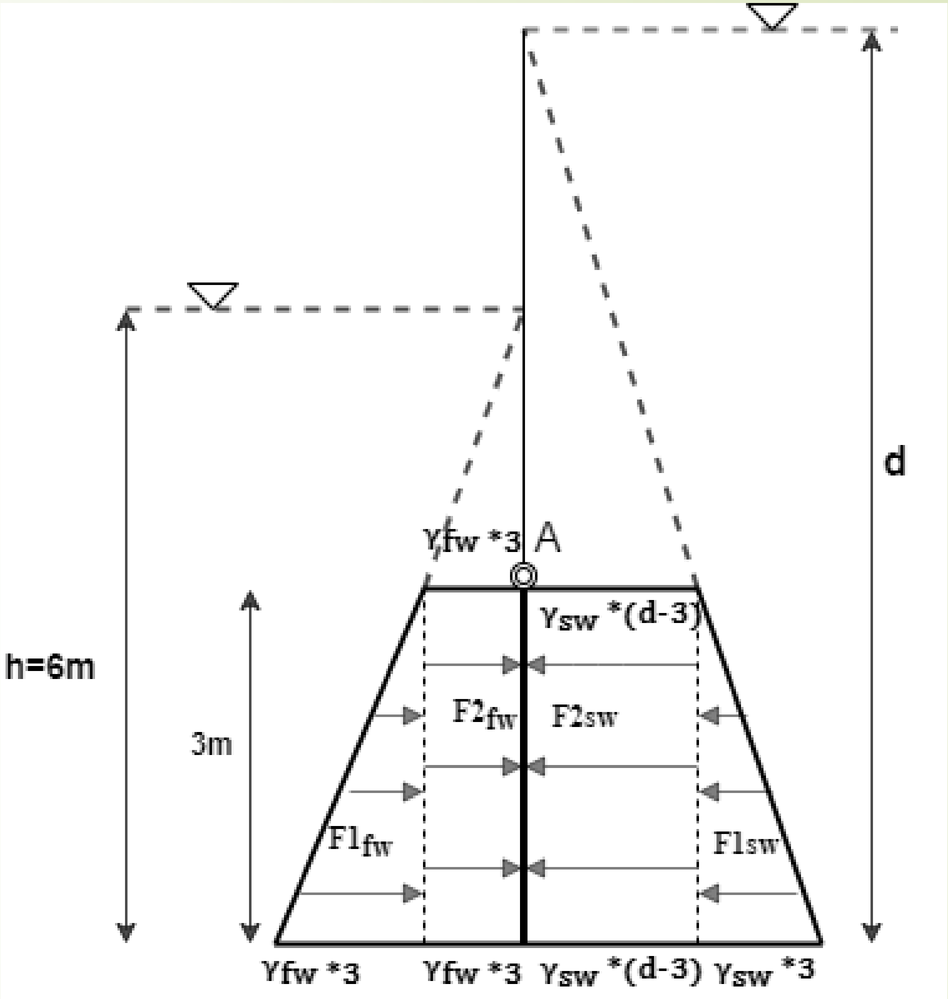
$$F_{sw,1} = \frac{1}{2} \times \gamma_{sw} \times 3 \times 3 \times 4 = 180.9\ kN$$

$$F_{sw,2} = \gamma_{sw} \times (d - 3) \times 3 \times 4 = 120.6(d - 3)\ kN$$

Moment at hinge A due to force of saltwater-

$$M_{sw,A} = F_{sw,1} \times \frac{2}{3} \times 3 + F_{sw,2} \times \frac{1}{2} \times 3$$

$$M_{A,sw} = 361.8 + 180.9\ (d - 3)\ \ kNm$$



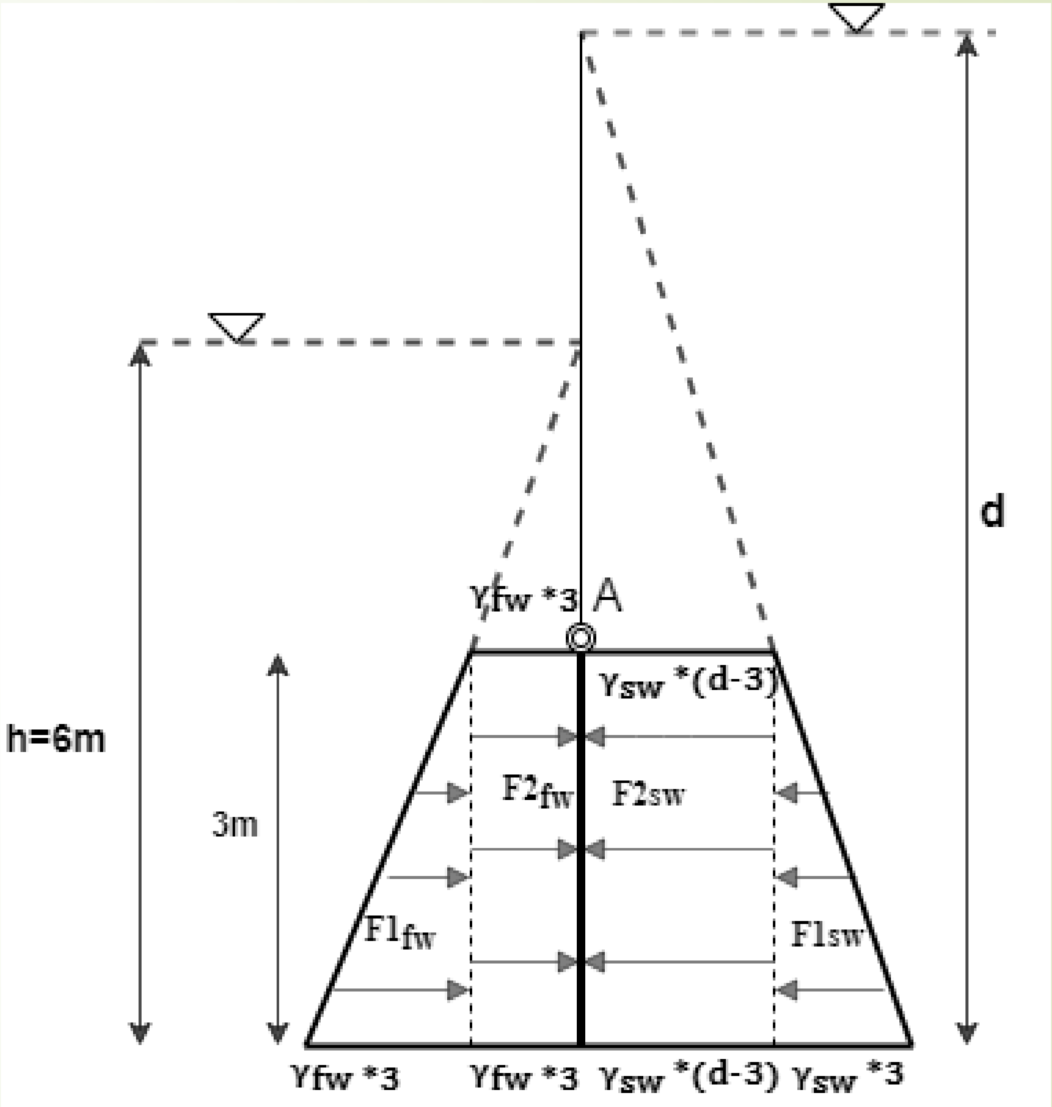
Solution #2

At hinge $\sum M_A = 0$

$$M_{A,fw} = M_{A,sw}$$

$$882.9 = 361.8 + 180.9(d-3)$$

$$\boxed{d = 5.88\ m}$$



Question # 3

3. Find the resultant of the wind forces on the advertising board shown in Fig. 3. The intensity of the wind force normal to the board is $10(1+z)\ N/m^2$, where z is the vertical distance from ground level.

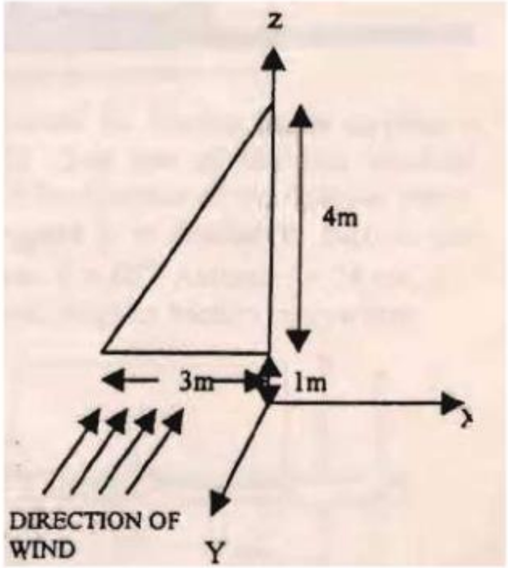


Fig. 3

Solution # 3

Force on the small element:

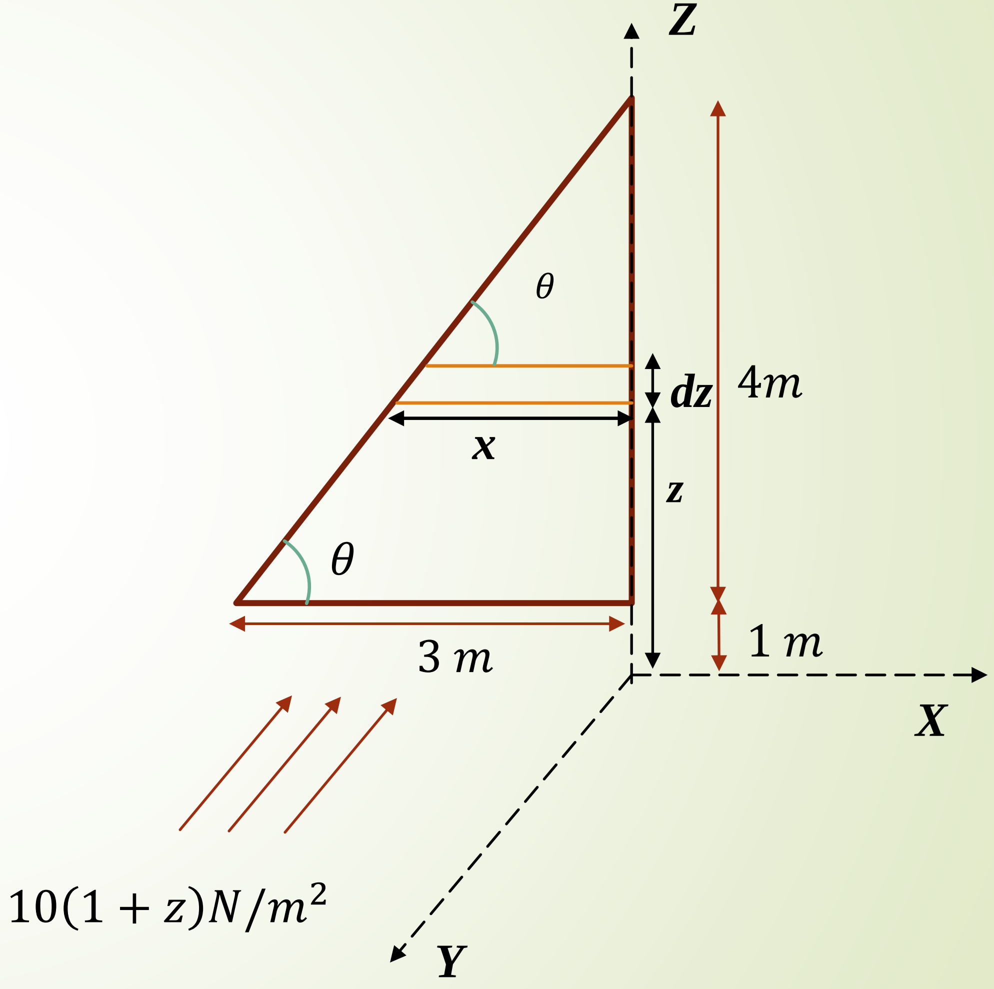
$$dF = 10(1+z)xdz(-\hat{j})$$

$$\tan\theta = \frac{4}{3} = \frac{4-(z-1)}{x} = \frac{5-z}{x}$$

$$x = \frac{3}{4}(5-z)$$

Putting value of x in dF

$$dF = 10(1+z) \times \frac{3}{4}(5-z)dz(-\hat{j})$$



Solution # 3

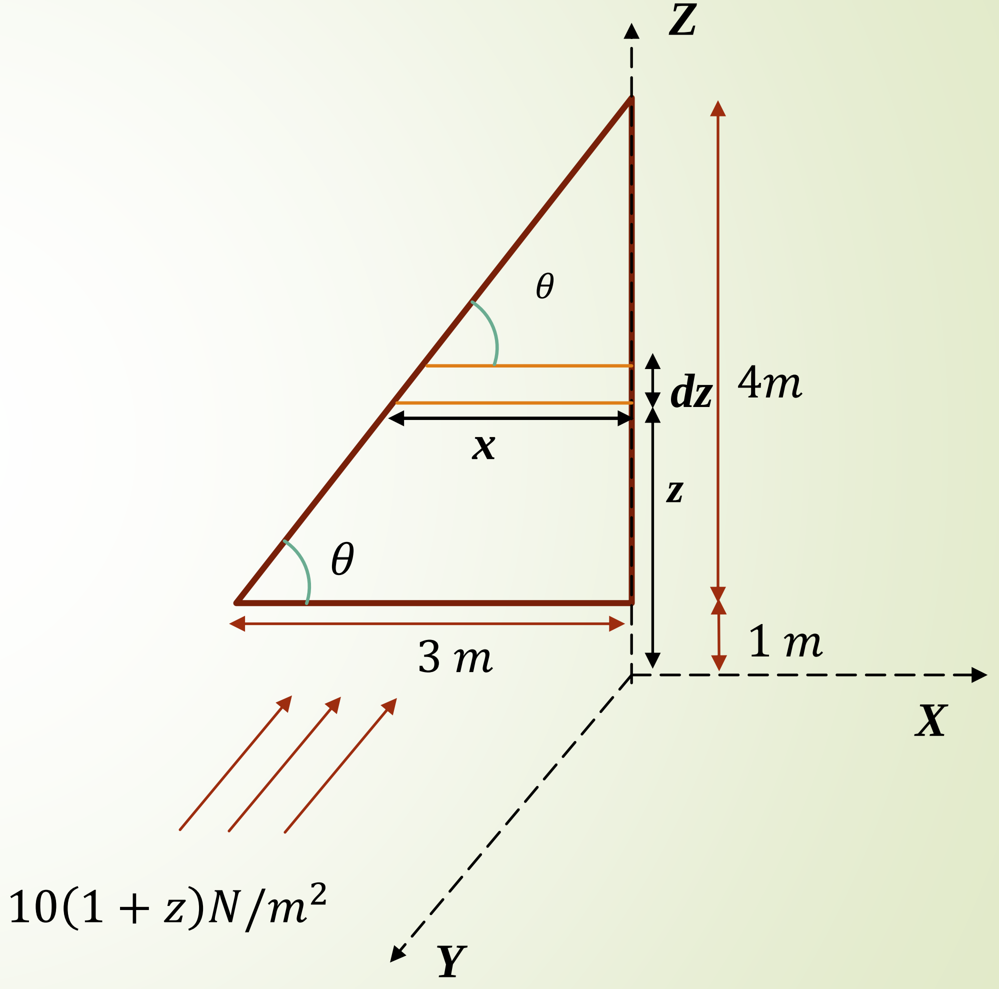
Integrating:

$$F = \int_1^5 \frac{15}{2}(5 + 4z - z^2)dz(-\hat{j})$$

$$= \frac{15}{2} \times \left[5z + 2z^2 - \frac{z^3}{3}\right]_{z=1}^{z=5}$$

$$= \frac{15}{2}\left(20 + 48 - \frac{124}{3}\right) = 200$$

$$\boxed{F = 200\,N(-\hat{j})}$$



Question # 4

4. Grain (8000 N/m^3 specific weight) is contained in a silo shown in Figure 4. The walls of the silo are fixed, and the door *ABCD*, can be opened to allow the grain to pour out. Door *ABCD* is flat with 20 cm depth (into the plane of the figure). In the position shown, the hydraulic cylinder *EG* is horizontal. Neglect the weights of the individual members. Determine the moment at D due to the pressure of grain on the door ABCD.

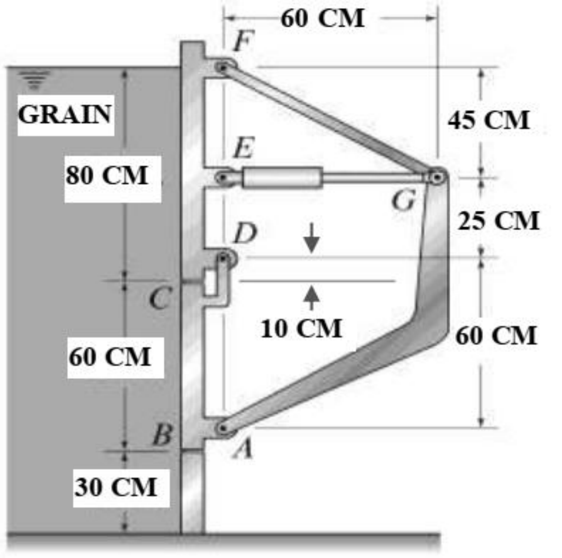


Fig. 4

Solution # 4

Pressure force on the door *ABCD* due to grain

$$P_1 = (0.8\,m) \times (8000\,N/m^3) \times (0.6\,m)(0.2\,m)$$

$$P_1 = 768\,N$$

$$P_2 = (8000\,N/m^3) \times \frac{1}{2} \times (0.6\,m) \times (0.6\,m) \times (0.2\,m)$$

$$P_2 = 288\,N$$

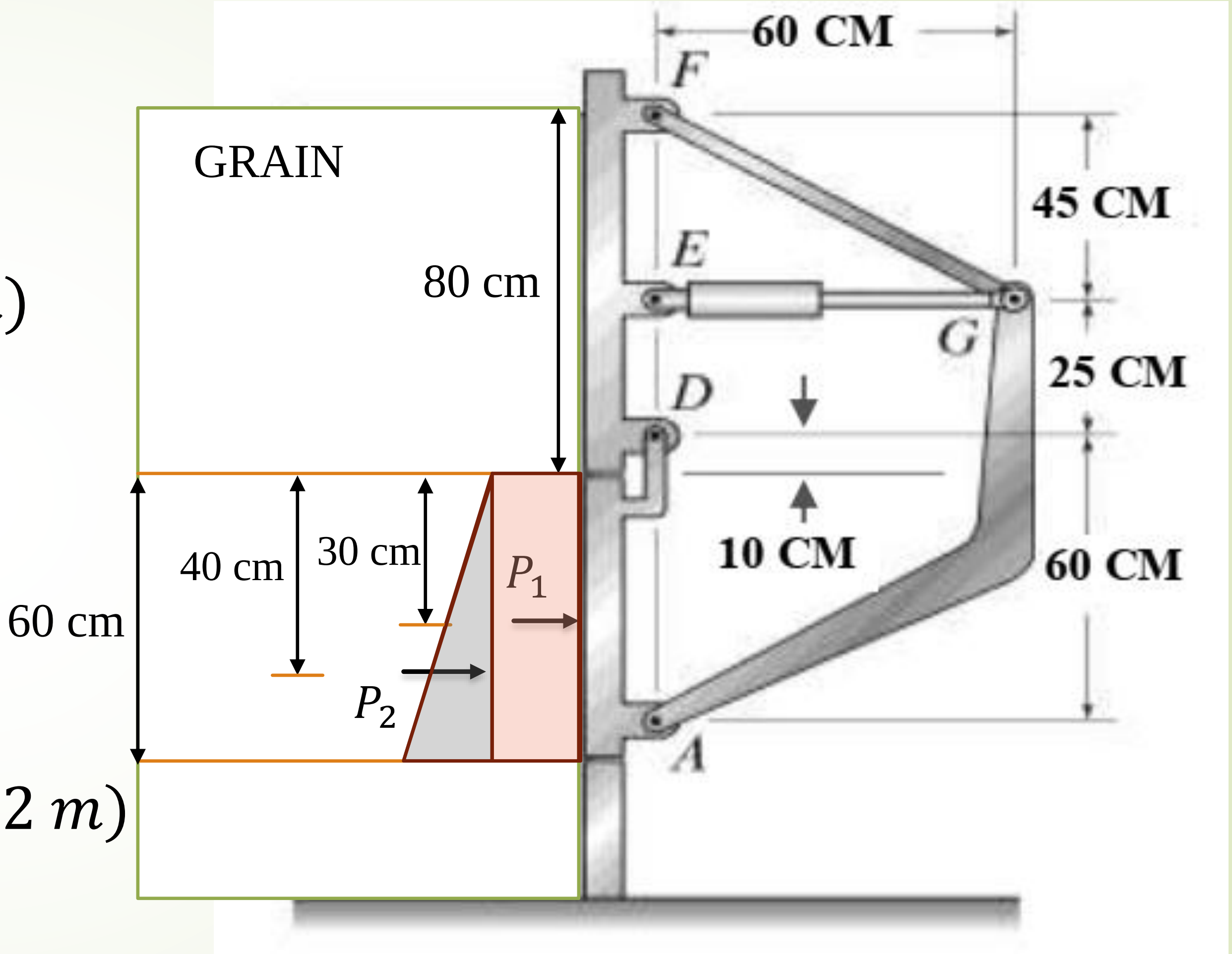


Fig. 4

Solution # 4

Taking moments due to P_1 and P_2 at hinge D

$$M_D = (0.4)P_1 + (0.5)P_2$$

$$M_D = (0.4)(768) + (0.5)(288)$$

$$\boxed{M_D = 451.2\ Nm(\hat{k})}$$

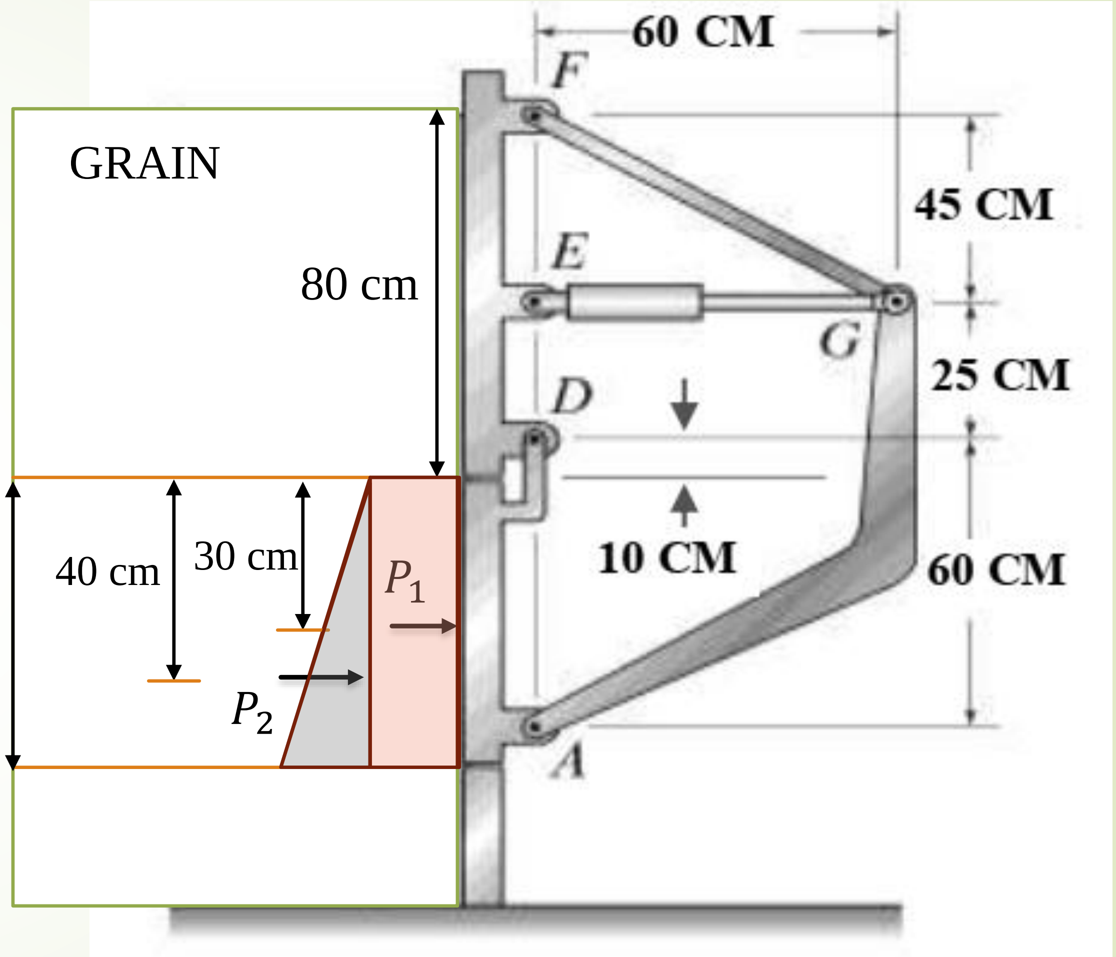


Fig. 4