CE-102 Tutorial Solutions

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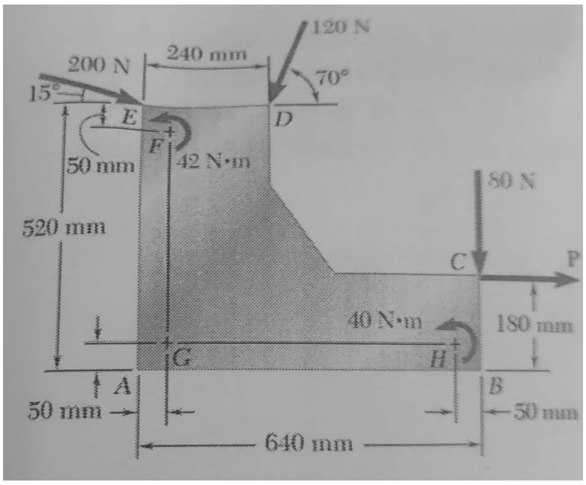
Tutorial-1

Q.1. Let us start with Q1



$\sum F_{\text{x}} = R_{\text{x}} = 212.2N$
$\sum F_{\text{y}} = R_{\text{y}} = -244.6N$

$$
\begin{aligned}
M_{\text{G}} =& 40 + 42 - (60 \times 0.13) - (80 \times 0.59) + (41.04 \times 0.47) - (112.8 \times 0.19) + 51.76 \times 0.05 \\
&+ 193.2 \times 0.47 \\
=& -63.36Nm
\end{aligned}
$$

Let the screw be at a position (x, y) For moment to be zero at this point

$$(x\hat{i} + y\hat{j}) \times (R_{\text{x}}\hat{i} + R_{\text{y}}\hat{j}) = -63.36\hat{k}$$

Solve the above equation for both the cases in the question.

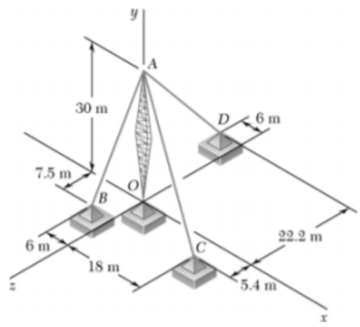
Q.2. Let $\overrightarrow{T}_{\text{AB}} = \overrightarrow{T}_1, \overrightarrow{T}_{\text{AD}} = \overrightarrow{T}_2, \overrightarrow{T}_{\text{AC}} = \overrightarrow{T}_3$

Let $\|\overrightarrow{T}_1\| = x, \|\overrightarrow{T}_2\| = y$

$\overrightarrow{T}_1 = \frac{-6\hat{i}-30\hat{j}+7.5\hat{k}}{31.5}x$

$\overrightarrow{T}_2 = \frac{-6\hat{i}-30\hat{j}-22.2\hat{k}}{37.8}y$

$\overrightarrow{T}_3 = \frac{18\hat{i}-30\hat{j}+5.4\hat{k}}{35.4}3.6$



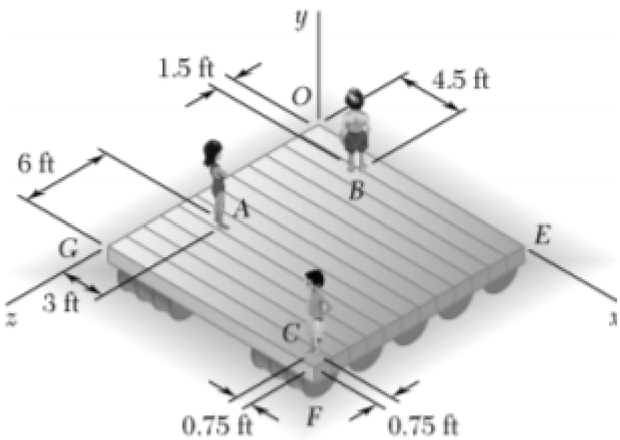
Since resultant of $\overrightarrow{T}_1$,$\overrightarrow{T}_2$ and $\overrightarrow{T}_3$ is vertical the i and k components in the resultant force must be equal to zero. Therefore we get

$$\frac{18 \times 3.6}{35.4} - \frac{6x}{31.5} - \frac{6y}{37.8} = 0 \tag{1}$$

$$\frac{5.4 \times 3.6}{35.4} + \frac{7.5x}{31.5} - \frac{22.2y}{37.8} = 0 \tag{2}$$

Solve (1) and (2) to get the value of $\boxed{x = 6.6kN, y = 3.61kN}$.

Q.3. Let the fourth chlid be at position $(x, 0, z)$.



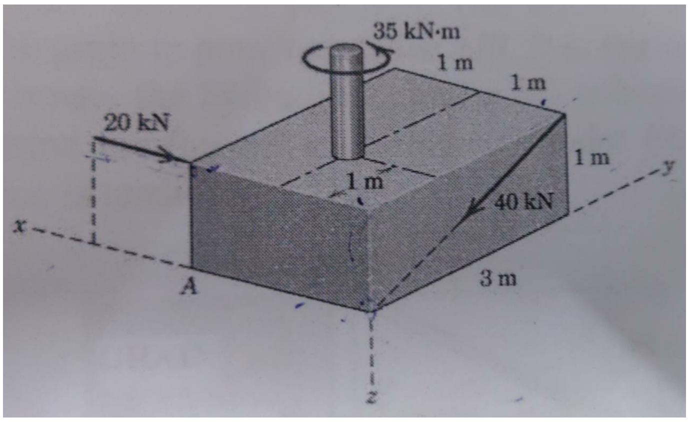
Taking O as the origin.
$A(1.5, 0, 9)$ $B(4.5, 0, 1.5)$ $C(14.25, 0, 14.25)$ $D(x, 0, z)$ Centre of raft $E(7.5, 0, 7.5)$
If resultant of four weights pass through the centre of the raft then torque about it should be equal to 0. Therefore

$$\overrightarrow{AE} \times (-85\hat{j}) + \overrightarrow{BE} \times (-60\hat{j}) + \overrightarrow{CE} \times (-90\hat{j}) + \overrightarrow{DE} \times (-95\hat{j}) = 0$$

$(-6\hat{\imath}+1.5\hat{k})\times(-85\hat{\jmath})+(-3\hat{\imath}-6\hat{k})\times(-60\hat{\jmath})+(6.75\hat{\imath}+6.75\hat{k})\times(-90\hat{\jmath})$
$+((x-7.5)\hat{\imath}+(z-7.5)\hat{k})\times(-95\hat{\jmath})=0$

Solving the above equation to get values of $\boxed{x=8.37m, z=3.55m}$.

Q.4. Let $\overrightarrow{F_1}=-20\hat{\imath}, \overrightarrow{F_2}=\frac{40}{\sqrt{10}}(-3\hat{\jmath}+\hat{k})$ and $\overrightarrow{M}=-35\hat{k}$



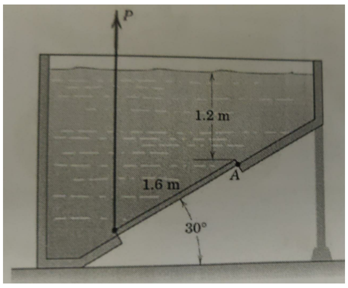
Let $\overrightarrow{r_1}=-1\hat{k}, \overrightarrow{r_2}=-2\hat{\imath}$
$\overrightarrow{M_1}=\overrightarrow{r_1}\times\overrightarrow{F_1}=20\hat{\jmath}$
$\overrightarrow{M_2}=\overrightarrow{r_2}\times\overrightarrow{F_2}=8\sqrt{10}\hat{\jmath}+24\sqrt{10}\hat{k}$

$$\overrightarrow{M_{\text{res}}}=\overrightarrow{M}+\overrightarrow{M_1}+\overrightarrow{M_2}$$
$$\overrightarrow{F_{\text{res}}}=\overrightarrow{F_1}+\overrightarrow{F_2}$$
$$M_{\text{wrench}}=\overrightarrow{M_{\text{res}}}\cdot\hat{F}_1$$

Find all the required quantities using the above three equations.

Tutorial-2

Q.1. We will be solving this question by breaking the pressure diagram into 2 parts, a rectangle and triangle and calculating force and point of application of force for both the parts individually.

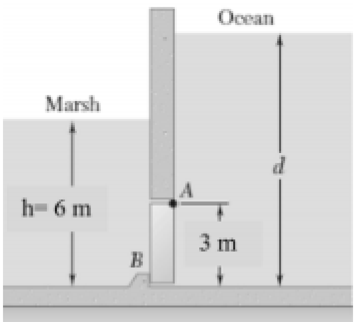


Force due to rectangular part $F_1 = (1.2\gamma \times 1.6)(0.8)$
Location of force F_1 $(x_1) = \frac{1.6}{2} = 0.8m$ from A.
Force due to triangular part $F_2 = (\frac{1}{2}0.8\gamma \times 1.6)(0.8)$
Location of force F_2 $(x_2) = \frac{2\times1.6}{3}m$ from A
Balancing torque about A gives

$$F_1x_1 + F_2x_2 = P\cos 30 \times 1.6$$

Solve the above equation to get the value of P.

Q.2. We will solve this question with the same approach as the last question.

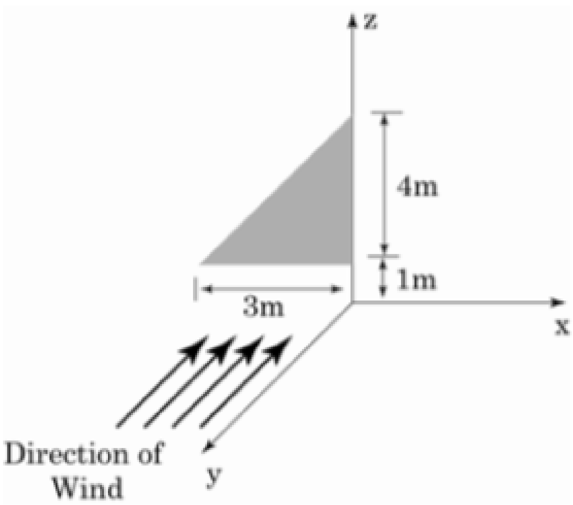


Now I will directly write the value and the position of the forces as I have shown it to you in the previous question.
Force due to rectangular part on marsh side $F_1 = 36\gamma_1$
Force due to rectangular part on ocean side $F_2 = (d - 3)12\gamma_2$

Location of force F_1 = Location of force $F_2 = \frac{3}{2}m$
Force due to triangular part on marsh side $F_3 = 18\gamma_1$
Force due to triangular part on ocean side $F_4 = 18\gamma_2$
Location of force F_3 = Location of force $F_4 = 2m$

Now balance torque about A to get the value of $\boxed{d = 5.88m}$.

Q.3. We can solve this question easily by integration(just like JEE).



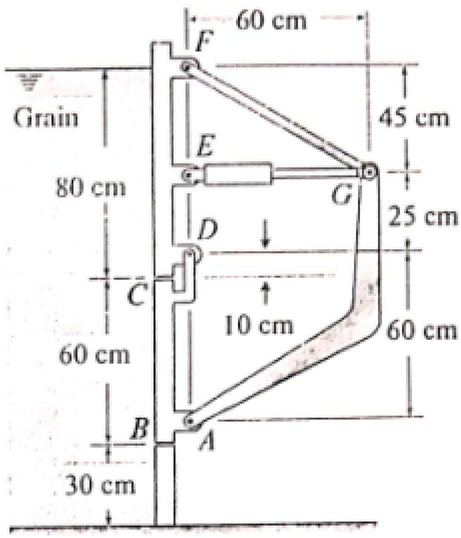
We take small rectangular(actually trapezium but we can approximate that to a rectangle since the element is infinitesimally small) elements along $z - axis$ and integrate ,the width of this element will be dz and length can be found out by similar triangles.

$$\frac{4}{3} = \frac{5-z}{l}$$
$$l = \frac{15-3z}{4}$$

Therefore area of our elment is $da = \frac{(15-3z)dz}{4}$
Intensity of wind force $I(z) = 10(1+z)$

$$F = \int_1^5 I(z)da$$
$$= \frac{10}{4}\int_1^5 (1+z)(15-3z)$$

$$\boxed{F = 200N}$$



Q.4. This question involves some of the concepts from tut3.
So we take