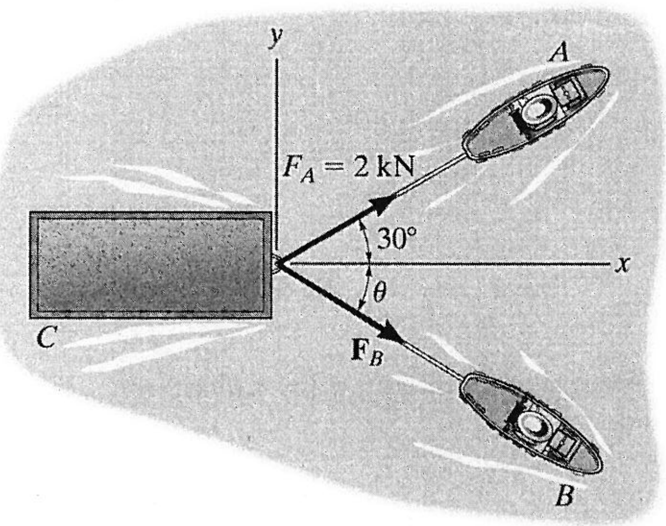
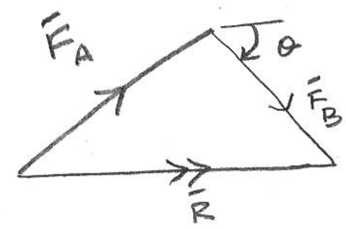
Q1. Two tug boats A, B apply forces $F_A$ and $F_B$ to pull the barge along a river as shown in the figure. Force $F_A$ has a magnitude of 2 kN and is inclined at an angle of 30° with the positive x-axis. The resultant of forces $F_A$ and $F_B$ is required to be along the positive x axis.

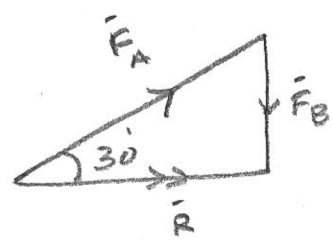
(1) Determine the magnitude of $F_B$ and angle θ if the value $F_B$ is to be the minimum.

(2) What is the magnitude of the resultant force in this case?



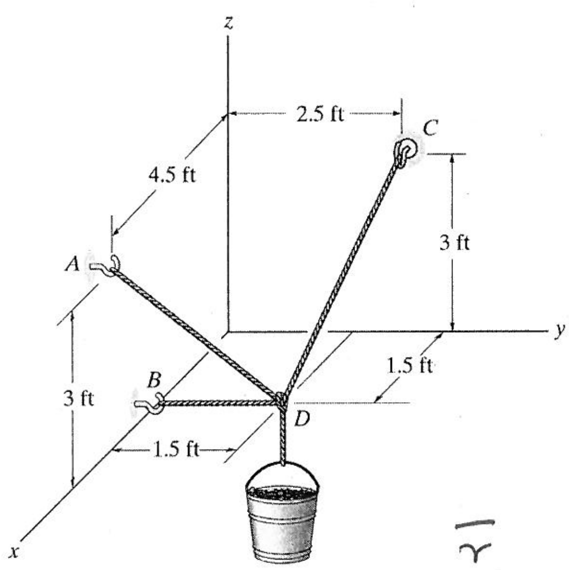

for $F_B$ to be minimum, $\theta = 90°$.




$|\bar{F}_B| = |\bar{F}_A| \sin 30 = 1$ kN.

$|\bar{R}| = F_A \cos 30 = \sqrt{3}$ kN.

Q2. If the bucket and its contents have a weight of 20 lb, determine the tension in cables DA, DB, and DC. (Note: Hook B is located on the x axis at a distance of 1.5 ft from the origin).

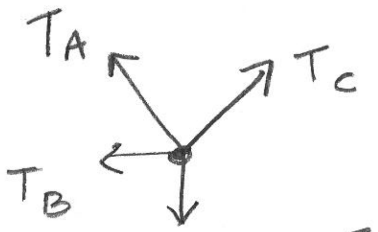



$A \equiv (4.5, 0, 3)$

$B \equiv (1.5, 0, 0)$

$C \equiv (0, 2.5, 3)$

$D \equiv (1.5, 1.5, 0)$




$W = -20\bar{k}$

$\bar{r}_{DB} = -1.5\bar{j}$ , $\bar{u}_{DB} = -\bar{j}$

$\bar{r}_{DA} = 3\bar{i} - 1.5\bar{j} + 3k$

$|\bar{r}_{DA}| = \sqrt{3^2 + 1.5^2 + 3^2}$

$= 4.5$ ft

$\therefore \bar{u}_{DA} = \frac{2}{3}\bar{i} - \frac{1}{3}\bar{j} + \frac{2}{3}\bar{k}$

$\bar{r}_{DC} = -1.5\bar{i} + 1\bar{j} + 3\bar{k}$

$|\bar{r}_{DC}| = \sqrt{1.5^2 + 1^2 + 3^2}$

$= 3.5$ ft

$\bar{u}_{DC} = -\frac{3}{7}\bar{i} + \frac{2}{7}\bar{j} + \frac{6}{7}\bar{k}$

$\bar{T}_A = T_A \cdot \bar{u}_{DA} = \frac{2T_A}{3}\bar{i} - \frac{T_A}{3}\bar{j} + \frac{2T_A}{3}\bar{k}$

$\bar{T}_B = T_B\, \bar{u}_{DB} = -T_B\bar{j}$

$\bar{T}_C = T_C \cdot \bar{u}_{DC} = -\frac{3T_C}{7}\bar{i} + \frac{2T_C}{7}\bar{j} + \frac{6T_C}{7}\bar{k}$

for $eq^{bm}$ $\bar{T}_A + \bar{T}_B + \bar{T}_C + \bar{W} = 0$

$$\left(\frac{2T_A}{3} - \frac{3T_C}{7}\right)\bar{i} + \left(-\frac{T_A}{3} - T_B + \frac{2T_C}{7}\right)\bar{j}$$

$$+ \left(\frac{2T_A}{3} + \frac{6T_C}{7} - 20\right)\bar{k} = 0$$

[3]

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$$\frac{2T_A}{3} - \frac{3T_C}{7} = 0 \quad \text{——— (1)}$$

$$-\frac{T_A}{3} - T_B + \frac{2T_C}{7} = 0 \quad \text{——— (2)}$$

$$\frac{2T_A}{3} + \frac{6T_C}{7} = 20 \quad \text{——— (3)}$$

(1) $\Rightarrow \frac{2T_A}{3} = \frac{3T_C}{7}$

Subst into (3) $\frac{3T_C}{7} + \frac{6T_C}{7} = 20$

$T_C = \frac{140}{9} = 15.6 \text{ lb}$

$\therefore T_A = \frac{3}{7}\left(\frac{140}{9}\right)\cdot\frac{3}{2}$

$= 10 \text{ lb}$

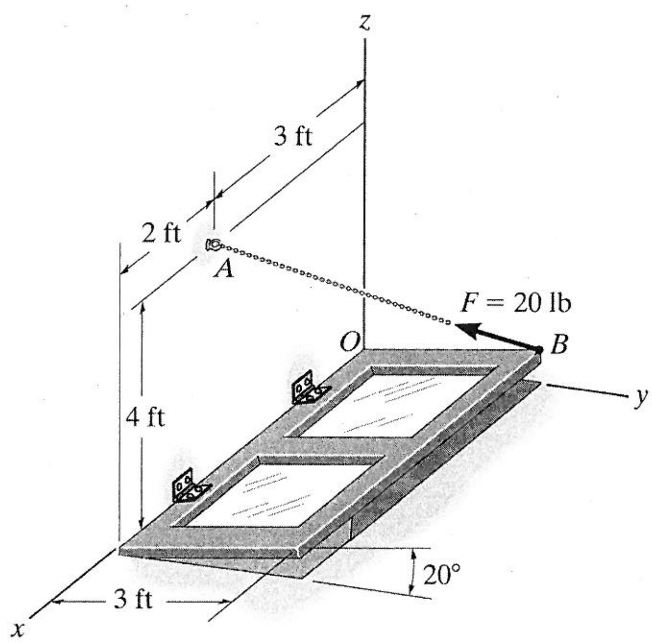
Subst into (2)

$T_B = 1.11 \text{ lb}$

[5]

Q2 sol^n contd... on this page

Q3. Chain AB exerts a force of 20-lb on the door at point B. Determine the magnitude of the moment of this force along the hinged axis of the door (i.e., x-axis).




$$A \equiv (3, 0, 4)$$

$$B \equiv (0, 3\cos 20, 3\sin 20)$$

$$\equiv (0, 2.819, 1.026)$$

$$\bar{r}_{BA} = 3\bar{i} - 2.819\bar{j} + 2.974\bar{k}$$

$$|\bar{r}_{BA}| = \sqrt{9 + 7.947 + 8.844}$$

$$= 5.078$$

$$\bar{u}_{BA} = \frac{3}{5.078}\bar{i} - \frac{2.819}{5.078}\bar{j} + \frac{2.974}{5.078}\bar{k}$$

$$= 0.591\bar{i} - 0.555\bar{j} + 0.586\bar{k}$$

$$\bar{T}_{BA} = 20\,\bar{u}_{BA}$$

$$= 11.82\bar{i} - 11.10\bar{j} + 11.71\bar{k}$$

$$\bar{M}_o = \bar{r}_{OA} \times \bar{T}_{BA}$$

$$M_x = \bar{M}_o \cdot \bar{i} = \begin{vmatrix} 1 & 0 & 0 \\ 3 & 0 & 4 \\ 11.82 & -11.10 & 11.71 \end{vmatrix}$$

$$= 44.4 \text{ lb.ft}$$