**PROBLEM 3.10**

The tailgate of a car is supported by the hydraulic lift \( BC \). If the lift exerts a 125-N force directed along its center line on the ball and socket at \( B \), determine the moment of the force about \( A \).

**SOLUTION**

First note \( d_{CB} = \sqrt{(344 \text{ mm})^2 + (152.4 \text{ mm})^2} = 376.25 \text{ mm} \)

Then \( \cos \theta = \frac{344 \text{ mm}}{376.25 \text{ mm}} \quad \sin \theta = \frac{152.4 \text{ mm}}{376.25 \text{ mm}} \)

and \( F_{CB} = (F_{CB} \cos \theta)i - (F_{CB} \sin \theta)j \)

\[ = \frac{125 \text{ N}}{376.25 \text{ mm}} [(344 \text{ mm})i + (152.4 \text{ mm})j] \]

Now \( \mathbf{M}_A = \mathbf{r}_{BiA} \times \mathbf{F}_{CB} \)

where \( \mathbf{r}_{BiA} = (410 \text{ mm})i - (87.6 \text{ mm})j \)

Then \( \mathbf{M}_A = [(410 \text{ mm})i - (87.6 \text{ mm})j] \times \frac{125 \text{ N}}{376.25} (344i - 152.4j) \)

\[ = (30.770 \text{ N} \cdot \text{mm})k \]

\[ = (30.770 \text{ N} \cdot \text{m})k \]

or \( \mathbf{M}_A = 30.8 \text{ N} \cdot \text{m} \)
PROBLEM 3.49

To lift a heavy crate, a man uses a block and tackle attached to the bottom of an I-beam at hook B. Knowing that the moments about the y and z axes of the force exerted at B by portion AB of the rope are, respectively, 100 lb-ft and -400 lb-ft, determine the distance \( a \).

\[ \text{SOLUTION} \]

Based on the following:

\[ \mathbf{M}_O = \mathbf{r}_{AO} \times \mathbf{T}_{BA} \]

where

\[ \mathbf{M}_O = M_x \mathbf{i} + M_y \mathbf{j} + M_z \mathbf{k} \]

\[ = M_x \mathbf{i} + \left( 100 \text{ lb-ft} \right) \mathbf{j} - \left( 400 \text{ lb-ft} \right) \mathbf{k} \]

\[ \mathbf{r}_{AO} = (6 \text{ ft}) \mathbf{i} + (4 \text{ ft}) \mathbf{j} \]

\[ \mathbf{T}_{BA} = \lambda_{BA} \mathbf{T}_{BA} \]

\[ = \frac{(6 \text{ ft}) \mathbf{i} - (12 \text{ ft}) \mathbf{j} - (a) \mathbf{k}}{d_{BA}} \mathbf{T}_{BA} \]

\[ = \frac{T_{BA}}{d_{BA}} \left[ -4a \mathbf{i} + (6a) \mathbf{j} - (96) \mathbf{k} \right] \]

\[ \therefore M_x \mathbf{i} + 100 \mathbf{j} - 400 \mathbf{k} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 6 & 4 & 0 \\ 6 & -12 & -d_{BA} \end{vmatrix} \mathbf{T}_{BA} \]

From j-coefficient:

\[ 100d_{AB} = 6aT_{BA} \quad \text{or} \quad T_{BA} = \frac{100}{6a}d_{BA} \quad (1) \]

From k-coefficient:

\[ -400d_{AB} = -96T_{BA} \quad \text{or} \quad T_{BA} = \frac{400}{96}d_{BA} \quad (2) \]

Equating Equations (1) and (2) yields

\[ a = \frac{100(96)}{6(400)} \]

or \( a = 4.00 \text{ ft} \).
**PROBLEM 3.69**

A couple \( M \) of magnitude 10 lb-ft is applied to the handle of a screwdriver to tighten a screw into a block of wood. Determine the magnitudes of the two smallest horizontal forces that are equivalent to \( M \) if they are applied (a) at corners \( A \) and \( D \), (b) at corners \( B \) and \( C \), (c) anywhere on the block.

**SOLUTION**

(a) Have

\[
M = Pd
\]

or

\[
10 \text{ lb-ft} = P(10 \text{ in.}) \left( \frac{1 \text{ ft}}{12 \text{ in.}} \right)
\]

\[\therefore P = 12 \text{ lb} \quad \text{or} \quad P_{\min} = 12.00 \text{ lb} \]

(b) Have

\[
d_{BC} = \sqrt{(BE)^2 + (EC)^2}
\]

\[= \sqrt{(10 \text{ in.})^2 + (6 \text{ in.})^2} = 11.6619 \text{ in.} \]

\[
M = Pd
\]

\[
10 \text{ lb-ft} = P(11.6619 \text{ in.}) \left( \frac{1 \text{ ft}}{12 \text{ in.}} \right)
\]

\[P = 10.2899 \text{ lb} \quad \text{or} \quad P = 10.29 \text{ lb} \]

(c) Have

\[
d_{AC} = \sqrt{(AD)^2 + (DC)^2}
\]

\[= \sqrt{(10 \text{ in.})^2 + (16 \text{ in.})^2} = 2\sqrt{89} \text{ in.} \]

\[
M = Pd_{AC}
\]

\[
10 \text{ lb-ft} = P(2\sqrt{89} \text{ in.}) \left( \frac{1 \text{ ft}}{12 \text{ in.}} \right)
\]

\[P = 6.3600 \text{ lb} \quad \text{or} \quad P = 6.36 \text{ lb} \]
PROBLEM 3.84

Three workers trying to move a 3 x 3 x 4-ft crate apply to the crate the three horizontal forces shown. (a) If $P = 60$ lb, replace the three forces with an equivalent force-couple system at $A$. (b) Replace the force-couple system of part $a$ with a single force, and determine where it should be applied to side $AB$. (c) Determine the magnitude of $P$ so that the three forces can be replaced with a single equivalent force applied at $B$.

SOLUTION

(a) Based on

\[ \sum F_x: \quad -50 \text{ lb} + 50 \text{ lb} + 60 \text{ lb} = F_A \]

\[ F_A = 60 \text{ lb} \]

or $F_A = (60.0 \text{ lb})\hat{k}$

Based on

\[ \sum M_A: \quad (50 \text{ lb})(2 \text{ ft}) - (50 \text{ lb})(0.6 \text{ ft}) = M_A \]

\[ M_A = 70 \text{ lb}\cdot\text{ft} \]

or $M_A = (70.0 \text{ lb}\cdot\text{ft})\hat{j}$

(b) Based on

\[ \sum F_x: \quad -50 \text{ lb} + 50 \text{ lb} + 60 \text{ lb} = F \]

\[ F = 60 \text{ lb} \]

or $F = (60.0 \text{ lb})\hat{k}$

Based on

\[ \sum M_A: \quad 70 \text{ lb}\cdot\text{ft} = 60 \text{ lb}(x) \]

\[ x = 1.16667 \text{ ft} \]

or $x = 1.167$ ft from $A$ along $AB$

(c) Based on

\[ \sum M_B: \quad -(50 \text{ lb})(1 \text{ ft}) + (50 \text{ lb})(2.4 \text{ ft}) - P(3 \text{ ft}) = R(0) \]

\[ P = \frac{70}{3} = 23.333 \text{ lb} \]

or $P = 23.3$ lb