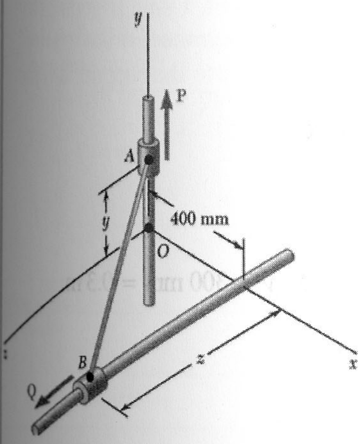
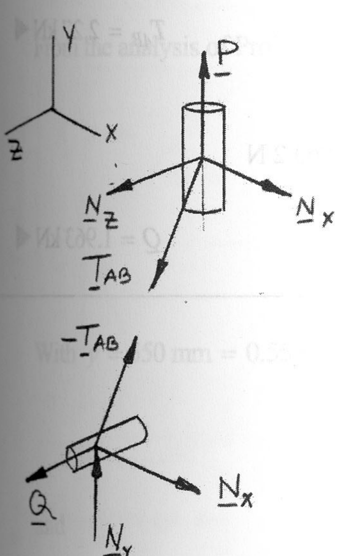
PROBLEM 2.127



Collars *A* and *B* are connected by a 1-m-long wire and can slide freely on frictionless rods. If a force **P** = (680 N)**j** is applied at *A*, determine (*a*) the tension in the wire when $y = 300$ mm, (*b*) the magnitude of the force **Q** required to maintain the equilibrium of the system.

SOLUTION

Free-Body Diagrams of collars



For both Problems 2.127 and 2.128:

$$(AB)^2 = x^2 + y^2 + z^2$$

Here $$(1\text{ m})^2 = (0.40\text{ m})^2 + y^2 + z^2$$

or $$y^2 + z^2 = 0.84\text{ m}^2$$

Thus, with y given, z is determined.

Now

$$\lambda_{AB} = \frac{\overrightarrow{AB}}{AB} = \frac{1}{1\text{ m}}(0.40\mathbf{i} - y\mathbf{j} + z\mathbf{k})\text{m} = 0.4\mathbf{i} - y\mathbf{j} + z\mathbf{k}$$

Where y and z are in units of meters, m.

From the F.B. Diagram of collar *A*:

$$\Sigma\mathbf{F} = 0: \quad N_x\mathbf{i} + N_z\mathbf{k} + P\mathbf{j} + T_{AB}\lambda_{AB} = 0$$

Setting the **j** coefficient to zero gives:

$$P - yT_{AB} = 0$$

With $P = 680$ N,

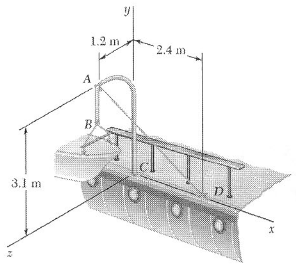
$$T_{AB} = \frac{680\text{ N}}{y} = 2267\text{ N}$$

Now, from the free body diagram of collar *B*:

$$\Sigma\mathbf{F} = 0: \quad N_x\mathbf{i} + N_y\mathbf{j} + Q\mathbf{k} - T_{AB}\lambda_{AB} = 0$$

Using the **k** components, Q - T * z = 0,
so Q = (2267) * (sqrt(.75)) = 1963 N

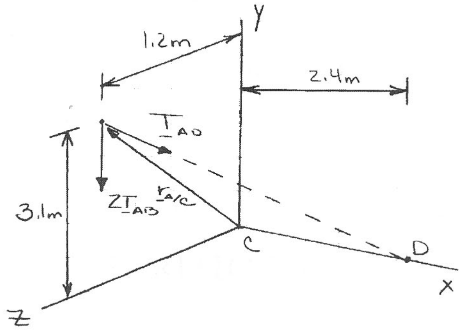
continued



PROBLEM 3.21

A small boat hangs from two davits, one of which is shown in the figure. The tension in line *ABAD* is 369 N. Determine the moment about *C* of the resultant force $\mathbf{R}_A$ exerted on the davit at *A*.

SOLUTION



With $\mathbf{T}_{AB} = -(369\text{ N})\mathbf{j}$

$$\mathbf{T}_{AB} = T_{AD}\frac{\overrightarrow{AD}}{AD} = (369\text{ N})\frac{(2.4\text{ m})\mathbf{i} - (3.1\text{ m})\mathbf{j} - (1.2\text{ m})\mathbf{k}}{\sqrt{(2.4\text{ m})^2 + (-3.1\text{ m})^2 + (-1.2\text{ m})^2}}$$

$$\mathbf{T}_{AD} = (216\text{ N})\mathbf{i} - (279\text{ N})\mathbf{j} - (108\text{ N})\mathbf{k}$$

Then $\mathbf{R}_A = 2\,\mathbf{T}_{AB} + \mathbf{T}_{AD}$

$$= (216\text{ N})\mathbf{i} - (1017\text{ N})\mathbf{j} - (108\text{ N})\mathbf{k}$$

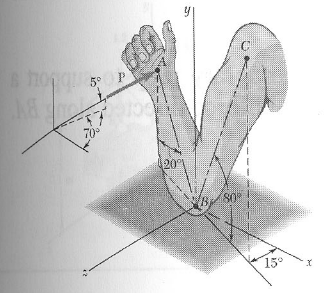
Also $\mathbf{r}_{A/C} = (3.1\text{ m})\mathbf{i} + (1.2\text{ m})\mathbf{k}$

Have $\mathbf{M}_C = \mathbf{r}_{A/C} \times \mathbf{R}_A$

$$= \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0 & 3.1 & 1.2 \\ 216 & -1017 & -108 \end{vmatrix} \text{N}\cdot\text{m}$$

$$= (885.6\text{ N}\cdot\text{m})\mathbf{i} + (259.2\text{ N}\cdot\text{m})\mathbf{j} - (669.6\text{ N}\cdot\text{m})\mathbf{k}$$

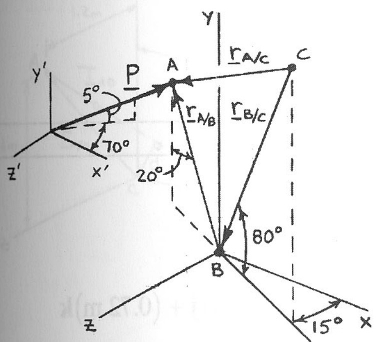
$$\mathbf{M}_C = (886\text{ N}\cdot\text{m})\mathbf{i} + (259\text{ N}\cdot\text{m})\mathbf{j} - (670\text{ N}\cdot\text{m})\mathbf{k} \blacktriangleleft$$



PROBLEM 3.25

In an arm wrestling contest, a 150-lb force **P** is applied to the hand of one of the contestants by his opponent. Knowing that $AB = 15.2$ in. and $BC = 16$ in., determine the moment of the force about C.

SOLUTION



Have $\mathbf{M}_C = \mathbf{r}_{A/C} \times \mathbf{P}$

where

$$\mathbf{r}_{A/C} = \mathbf{r}_{B/C} + \mathbf{r}_{A/B}$$

$$= (16 \text{ in.})(-\cos 80° \cos 15° \mathbf{i} - \sin 80° \mathbf{j} - \cos 80° \sin 15° \mathbf{k})$$

$$+ (15.2 \text{ in.})(-\sin 20° \cos 15° \mathbf{i} + \cos 20° \mathbf{j} - \sin 20° \sin 15° \mathbf{k})$$

$$= -(7.7053 \text{ in.})\mathbf{i} - (1.47360 \text{ in.})\mathbf{j} - (2.0646 \text{ in.})\mathbf{k}$$

and

$$\mathbf{P} = (150 \text{ lb})(\cos 5° \cos 70° \mathbf{i} + \sin 5° \mathbf{j} - \cos 5° \sin 70° \mathbf{k})$$

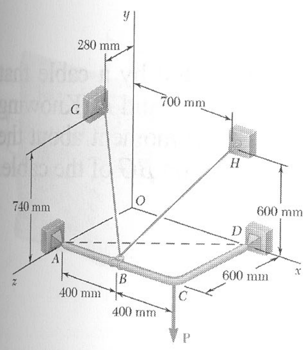
$$= (51.108 \text{ lb})\mathbf{i} + (13.0734 \text{ lb})\mathbf{j} - (140.418 \text{ lb})\mathbf{k}$$

Then

$$\mathbf{M}_C = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ -7.7053 & -1.47360 & -2.0646 \\ 51.108 & 13.0734 & -140.418 \end{vmatrix} \text{ lb}\cdot\text{in.}$$

$$= (233.91 \text{ lb}\cdot\text{in.})\mathbf{i} - (1187.48 \text{ lb}\cdot\text{in.})\mathbf{j} - (25.422 \text{ lb}\cdot\text{in.})\mathbf{k}$$

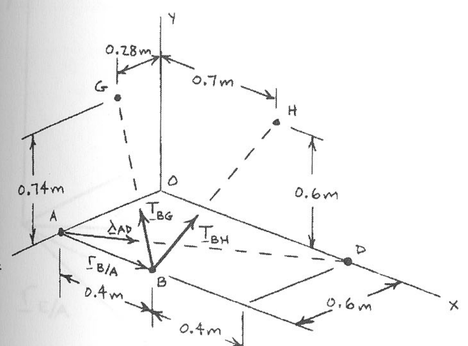
or $\mathbf{M}_C = (19.49 \text{ lb}\cdot\text{ft})\mathbf{i} - (99.0 \text{ lb}\cdot\text{ft})\mathbf{j} - (2.12 \text{ lb}\cdot\text{ft})\mathbf{k}$ ◀



PROBLEM 3.53

The frame *ACD* is hinged at *A* and *D* and is supported by a cable that passes through a ring at *B* and is attached to hooks at *G* and *H*. Knowing that the tension in the cable is 1125 N, determine the moment about the diagonal *AD* of the force exerted on the frame by portion *BH* of the cable.

SOLUTION



Have $$M_{AD} = \lambda_{AD} \cdot (\mathbf{r}_{B/A} \times \mathbf{T}_{BH})$$

where $$\lambda_{AD} = \frac{(0.8 \text{ m})\mathbf{i} - (0.6 \text{ m})\mathbf{k}}{\sqrt{(0.8 \text{ m})^2 + (-0.6 \text{ m})^2}} = 0.8\mathbf{i} - 0.6\mathbf{k}$$

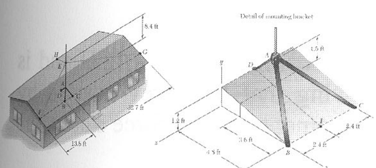
$$\mathbf{r}_{B/A} = (0.4 \text{ m})\mathbf{i}$$

$$\mathbf{T}_{BH} = T_{BH}\frac{\overrightarrow{BH}}{BH} = (1125 \text{ N})\frac{[(0.3 \text{ m})\mathbf{i} + (0.6 \text{ m})\mathbf{j} - (0.6 \text{ m})\mathbf{k}]}{\sqrt{(0.3)^2 + (0.6)^2 + (-0.6)^2} \text{ m}}$$

Then

$$M_{AD} = \begin{vmatrix} 0.8 & 0 & -0.6 \\ 0.4 & 0 & 0 \\ 375 & 750 & -750 \end{vmatrix} = -180 \text{ N}\cdot\text{m}$$

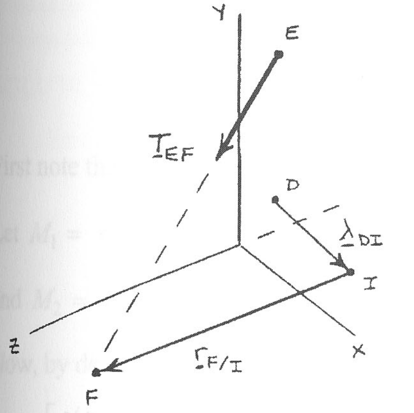
or $M_{AD} = -180.0 \text{ N}\cdot\text{m}$ ◀



PROBLEM 3.59

A mast is mounted on the roof of a house using bracket *ABCD* and is guyed by cables *EF*, *EG*, and *EH*. Knowing that the force exerted by cable *EF* at *E* is 29.7 lb, determine the moment of that force about the line joining points *D* and *I*.

SOLUTION



Have $M_{DI} = \boldsymbol{\lambda}_{DI} \cdot \left(\mathbf{r}_{F/I} \times \mathbf{T}_{EF}\right)$

where $\boldsymbol{\lambda}_{DI} = \dfrac{\overrightarrow{DI}}{DI} = \dfrac{(4.8 \text{ ft})\mathbf{i} - (1.2 \text{ ft})\mathbf{j}}{\sqrt{(4.8 \text{ ft})^2 + (-1.2 \text{ ft})^2}}$

$$= 0.97014\mathbf{i} - 0.24254\mathbf{j}$$

$$\mathbf{r}_{F/I} = (16.2 \text{ ft})\mathbf{k}$$

$$\mathbf{T}_{EF} = T_{EF}\frac{\overrightarrow{EF}}{EF} = (29.7 \text{ lb})\frac{\left[(3.6 \text{ ft})\mathbf{i} - (10.8 \text{ ft})\mathbf{j} + (16.2 \text{ ft})\mathbf{k}\right]}{\sqrt{(3.6 \text{ ft})^2 + (-10.8 \text{ ft})^2 + (16.2 \text{ ft})^2}}$$

$$= (5.4 \text{ lb})\mathbf{i} - (16.2 \text{ lb})\mathbf{j} + (24.3 \text{ lb})\mathbf{k}$$

Then

$$M_{DI} = \begin{vmatrix} 0.97014 & -0.24254 & 0 \\ 0 & 0 & 16.2 \\ 5.4 & -16.2 & 24.3 \end{vmatrix} \text{lb}\cdot\text{ft}$$

$$= -21.217 + 254.60$$

$$= 233.39 \text{ lb}\cdot\text{ft}$$

or $M_{DI} = 233 \text{ lb}\cdot\text{ft}$ ◀