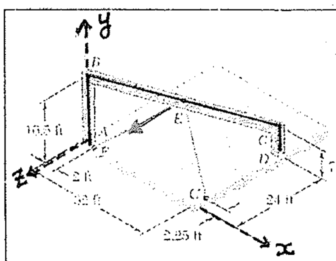
Good / Excellent



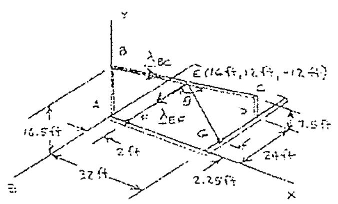
PROBLEM 3.39

Steel framing members AB, BC, and CD are joined at B and C and are braced using cables EF and EG. Knowing that E is at the midpoint of BC and that the tension in cable EF is 110 lb, determine (*a*) the angle between EF and member BC, (*b*) the projection on BC of the force exerted by cable EF at point E.

Also: Find $\vec{M}_B$ (due to $\vec{T}_{EF}$) ??

Find M_{BC} ??

SOLUTION



(*a*) By definition

$$\lambda_{BC} * \lambda_{EF} = (1)(1)\cos\theta$$

$\frac{\vec{BC}}{BC} \cdot \frac{\vec{EF}}{EF} = \frac{|BC| * |EF|}{BC \;\; EF} \cos\theta$

$\lambda_{BC} \cdot \lambda_{EF} = (1)(1)\cos\theta$

where

$$\lambda_{BC} = \frac{(32 \text{ ft})\mathbf{i} - (9 \text{ ft})\mathbf{j} - (24 \text{ ft})\mathbf{k}}{\sqrt{(32)^2 + (-9)^2 + (-24)^2} \text{ ft}}$$

$$= \frac{1}{41}(32\mathbf{i} - 9\mathbf{j} - 24\mathbf{k})$$

$$\lambda_{EF} = \frac{-(14 \text{ ft})\mathbf{i} - (12 \text{ ft})\mathbf{j} + (12 \text{ ft})\mathbf{k}}{\sqrt{(-14)^2 + (-12)^2 + (12)^2} \text{ ft}}$$

$$= \frac{1}{11}(-7\mathbf{i} - 6\mathbf{j} + 6\mathbf{k})$$

Therefore

$$\frac{(32\mathbf{i} - 9\mathbf{j} - 24\mathbf{k})}{41} \cdot \frac{(-7\mathbf{i} - 6\mathbf{j} + 6\mathbf{k})}{11} = \cos\theta$$

$$(32)(-7) + (-9)(-6) + (-24)(6) = (41)(11)\cos\theta$$

$$\cos\theta = -0.69623$$

or $\theta = 134.1°$ ◀

(*b*) By definition

$$(T_{EF})_{\text{on } BC} = (T_{EF})\cos\theta$$

$\vec{T}_{EF} \cdot \hat{\lambda}_{BC} = (T_{EF})_{\text{axis } BC}$

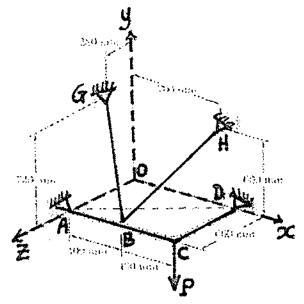
$$= (110 \text{ lb})(-0.69623)$$

$|T_{EF}| * |1| * \cos\theta = (T_{EF})_{BC}$

$$= -76.585 \text{ lb}$$

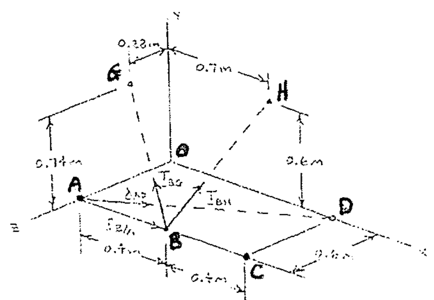
or $(T_{EF})_{BC} = -76.6$ lb ◀

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

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

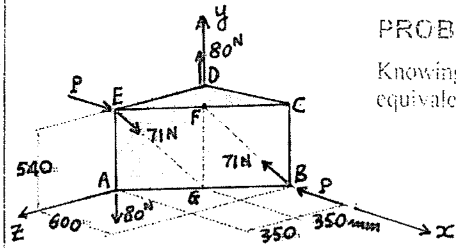
$$\mathbf{r}_{B/A} = (0.4\text{ m})\mathbf{i}$$

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

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 3.74

Knowing that $P = 0$, replace the two remaining couples with a single equivalent couple, specifying its magnitude and the direction of its axis.

SOLUTION

Have $\mathbf{M} = \mathbf{M}_1 + \mathbf{M}_2$

Where $\mathbf{M}_1 = \mathbf{r}_{E/D} \times \mathbf{F}_D$

$$= -(0.7\text{ m})\mathbf{k} \times (80\text{ N})\mathbf{j}$$

$$= (56.0\text{ N}\cdot\text{m})\mathbf{i}$$

And $\mathbf{M}_2 = \mathbf{r}_{G/F} \times \mathbf{F}_B$

Now $d_{BF} = \sqrt{(-0.300\text{ m})^2 + (0.540\text{ m})^2 + (0.350\text{ m})^2}$

$$= 0.710\text{ m}$$

Then $\mathbf{F}_B = \lambda_{BF} F_B$

$$= \frac{(-0.300\text{ m})\mathbf{i} + (0.540\text{ m})\mathbf{j} + (0.350\text{ m})\mathbf{k}}{0.710\text{ m}}(71\text{ N})$$

$$= -(30\text{ N})\mathbf{i} + (54\text{ N})\mathbf{j} + (35\text{ N})\mathbf{k}$$

$\therefore$ $\mathbf{M}_2 = (0.54\text{ m})\mathbf{j} \times \left[-(30\text{ N})\mathbf{i} + (54\text{ N})\mathbf{j} + (35\text{ N})\mathbf{k}\right]$

$$= (18.90\text{ N}\cdot\text{m})\mathbf{i} + (16.20\text{ N}\cdot\text{m})\mathbf{k}$$

Finally $\mathbf{M} = (56.0\text{ N}\cdot\text{m})\mathbf{i} + \left[(18.90\text{ N}\cdot\text{m})\mathbf{i} + (16.20\text{ N}\cdot\text{m})\mathbf{k}\right]$

$$= (74.9\text{ N}\cdot\text{m})\mathbf{i} + (16.20\text{ N}\cdot\text{m})\mathbf{k}$$

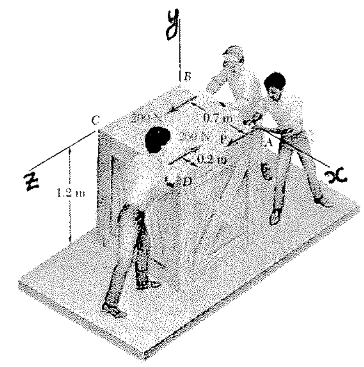
and $M = \sqrt{(74.9\text{ N}\cdot\text{m})^2 + (16.20\text{ N}\cdot\text{m})^2}$

$$= 76.632\text{ N}\cdot\text{m}$$

or $M = 76.6\text{ N}\cdot\text{m}$ ◀

$$\cos\theta_x = \frac{74.9}{76.632} \qquad \cos\theta_y = \frac{0}{76.632} \qquad \cos\theta_z = \frac{16.20}{76.632}$$

or $\theta_x = 12.20°$ $\quad \theta_y = 90.0°$ $\quad \theta_z = 77.8°$ ◀

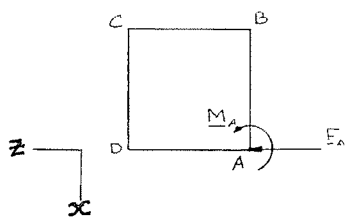


PROBLEM 3.85

Three workers trying to move a $1 \times 1 \times 1.2$-m crate apply to the crate the three horizontal forces shown. (*a*) If P = 240 N, 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 ΣF_z:

$$-200 \text{ N} + 200 \text{ N} + 240 \text{ N} = F_A$$

$$F_A = 240 \text{ N}$$

or $\mathbf{F}_A = (240 \text{ N})\mathbf{k}$ ◀

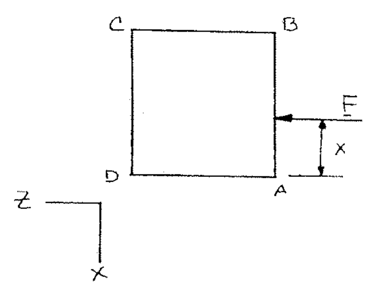
Based on ΣM_A:

$$(200 \text{ N})(0.7 \text{ m}) - (200 \text{ N})(0.2 \text{ m}) = M_A$$

$$M_A = 100 \text{ N}\cdot\text{m}$$

or $\mathbf{M}_A = (100.0 \text{ N}\cdot\text{m})\mathbf{j}$ ◀

(*b*)



Based on ΣF_z:

$$-200 \text{ N} + 200 \text{ N} + 240 \text{ N} = F$$

$$F = 240 \text{ N}$$

or $\mathbf{F} = (240 \text{ N})\mathbf{k}$ ◀

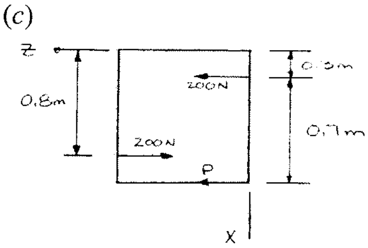
Based on ΣM_A:

$$100 \text{ N}\cdot\text{m} = (240 \text{ N})(x)$$

$$x = 0.41667 \text{ m}$$

or $x = 0.417$ m From A along AB ◀

(*c*)



Based on ΣM_B:

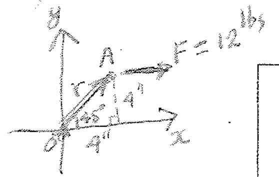
$$-(200 \text{ N})(0.3 \text{ m}) + (200 \text{ N})(0.8 \text{ m}) - P(1 \text{ m}) = R(0)$$

$$P = 100 \text{ N}$$

or $P = 100.0$ N ◀

$|\vec{r} \times \vec{F}| \equiv$ Force * perpendicular distance

Excellent! for clean example



$\vec{M}_o = \vec{r} \times \vec{F}$

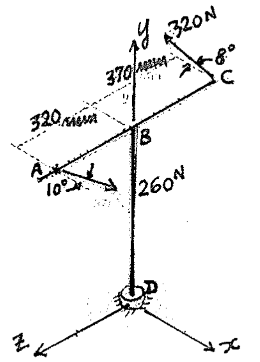
$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 4'' & 4'' & 0'' \\ 12\text{ lbs} & 0 & 0 \end{vmatrix}$

$= (\vec{0}) - (48\hat{k})$

Also: $|\vec{M}_o|$ = Force * perpend. distance

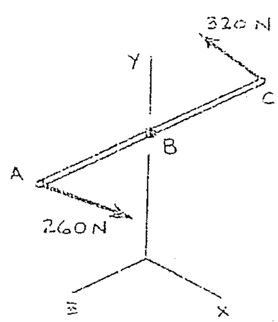
$= 12\text{ lbs} * 4''$

PROBLEM 3.86



To open an in-ground water valve, two workers apply the two horizontal forces shown to the handle of a valve wrench. Show that these forces are equivalent to a single force and specify, if possible, the point of application of the single force on handle ABC.

SOLUTION



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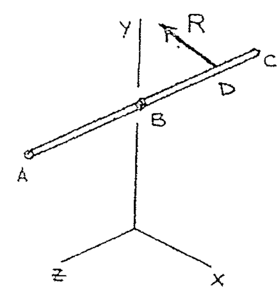


Let R be the single equivalent force...

ΣF: $\quad \mathbf{R} = \mathbf{F}_A + \mathbf{F}_C$

$= (260\text{ N})(\cos 10°\mathbf{i} - \sin 10°\mathbf{k}) + (320\text{ N})(-\cos 8°\mathbf{i} - \sin 8°\mathbf{k})$

$= -(60.836\text{ N})\mathbf{i} - (89.684\text{ N})\mathbf{k}$

or $\mathbf{R} = -(60.8\text{ N})\mathbf{i} - (89.7\text{ N})\mathbf{k}$ ◀

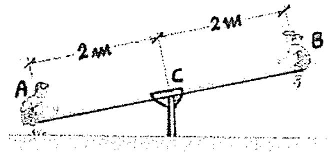
ΣM_A: $\quad r_{AD}R_x = r_{AC}F_C\cos 8°$

$r_{AD}(60.836\text{ N}) = (0.690\text{ m})(320\text{ N})\cos 8°$

$r_{AD} = 3.5941\text{ m}$

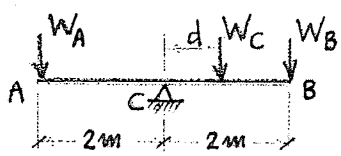
∴ R Would have to be applied 3.59 m to the right of A ◀ on an extension of handle ABC.

PROBLEM 3.102



The masses of two children sitting at ends A and B of a seesaw are 38 kg and 29 kg, respectively. Determine where a third child should sit so that the resultant of the weights of the three children will pass through C if she has a mass of (*a*) 27 kg, (*b*) 24 kg.

SOLUTION



First $\qquad W_A = m_A g = (38 \text{ kg})g$

$$W_B = m_B g = (29 \text{ kg})g$$

(*a*) $\qquad W_C = m_C g = (27 \text{ kg})g$

For resultant weight to act at C, $\qquad \Sigma M_C = 0$

Then $\qquad [(38 \text{ kg})g](2 \text{ m}) - [(27 \text{ kg})g](d) - [(29 \text{ kg})g](2 \text{ m}) = 0$

$$\therefore \quad d = \frac{76 - 58}{27} = 0.66667 \text{ m}$$

or $d = 0.667$ m ◀

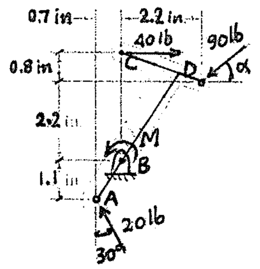
(*b*) $\qquad W_C = m_C g = (24 \text{ kg})g$

For resultant weight to act at C, $\qquad \Sigma M_C = 0$

Then $\qquad [(38 \text{ kg})g](2 \text{ m}) - [(24 \text{ kg})g](d) - [(29 \text{ kg})g](2 \text{ m}) = 0$

$$\therefore \quad d = \frac{76 - 58}{24} = 0.75 \text{ m}$$

or $d = 0.750$ m ◀



PROBLEM 3.107

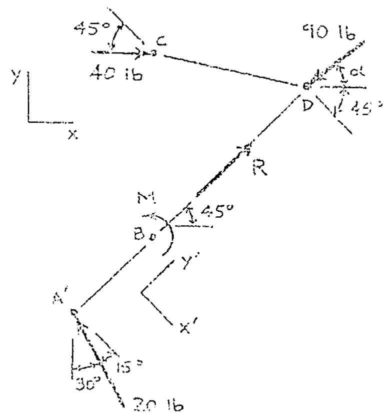
When the couple **M** is applied to the link in a mechanism, the resulting forces exerted on the link from a guide and the connecting links are as shown. Determine (*a*) the values of *M* and α so that the applied forces and couple can be reduced to a single equivalent force whose line of action passes through points *B* and *D*, (*b*) the equivalent force.

SOLUTION

(*a*) Have $+\circlearrowleft \Sigma M_D$: $\quad 0 = M - (0.8 \text{ in.})(40 \text{ lb}) - (2.9 \text{ in.})(20 \text{ lb})\cos 30° - (3.3 \text{ in.})(20 \text{ lb})\sin 30°$

or $M = 115.229$ lb·in.

or $\quad \mathbf{M} = 115.2$ lb·in. $\circlearrowleft$ ◀



Now, **R** is oriented at 45° as shown (since its line of action passes through *B* and *D*).

Have $\Sigma F_{x'}$: $\quad 0 = (40 \text{ lb})\cos 45° - (20 \text{ lb})\cos 15° - (90 \text{ lb})\cos(\alpha + 45°)$

or $\alpha = 39.283°$

or $\quad \alpha = 39.3°$ ◀

(*b*) ΣF_x: $\quad R_x = 40 - 20\sin 30° - 90\cos 39.283°$

$= -39.663$ lb

Now $\quad R = \sqrt{2} R_x$

or $\quad \mathbf{R} = 56.1$ lb ↙ 45.0° ◀