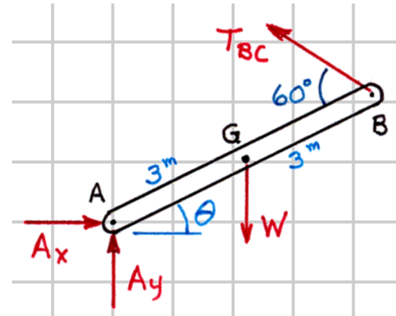
1-52

$$W = 250(9.81) = 2452.50 \text{ N}$$

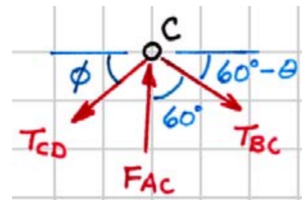


(a) From a free-body diagram of the post AB, moment equilibrium gives

$$\circlearrowleft \Sigma M_B = 0: \qquad 6(T_{BC}\sin 60°) - (3\cos\theta)W = 0$$

$$T_{BC} = \frac{(2452.50)(3\cos\theta)}{6\sin 60°}$$

Since the pin at A is frictionless and the weight of the brace AC is neglected, the brace AC is a two-force member and from a free-body diagram of the pin C, the equations of equilibrium give



$$\rightarrow \Sigma F_x = 0: \qquad F_{AC}\cos(60° + \theta) + T_{BC}\cos(60° - \theta) - T_{CD}\cos\phi = 0$$

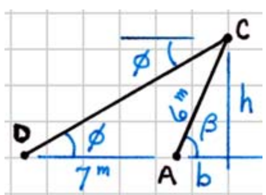
$$\uparrow \Sigma F_y = 0: \qquad F_{AC}\sin(60° + \theta) - T_{BC}\sin(60° - \theta) - T_{CD}\sin\phi = 0$$

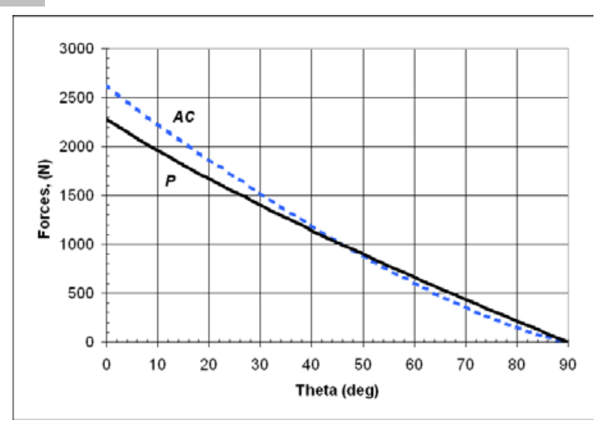
$$F_{AC} = \frac{\cos(60° - \theta)\sin\phi + \sin(60° - \theta)\cos\phi}{\sin(60° + \theta)\cos\phi - \cos(60° + \theta)\sin\phi} T_{BC}$$

$$T_{CD} = \frac{F_{AC}\cos(60° + \theta) + T_{BC}\cos(60° - \theta)}{\cos\phi} = P$$

in which

$$\tan\phi = \frac{6\sin\beta}{7 + 6\cos\beta} = \frac{6\sin(60° + \theta)}{7 + 6\cos(60° + \theta)}$$

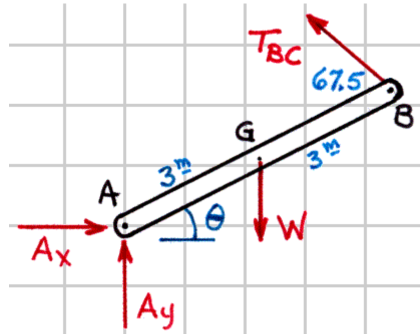




For this arrangement, the force P necessary to start raising the post (2300 N) is almost as large as the weight of the post (2450 N).

1-52 (cont.)

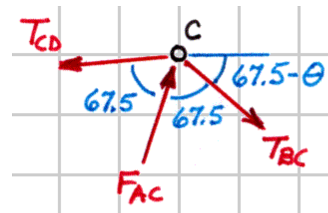
(b) From a free-body diagram of the post *AB*, moment equilibrium now gives



$$\circlearrowleft \Sigma M_B = 0: \quad 6\left(T_{BC}\sin 67.5°\right) - \left(3\cos\theta\right)W = 0$$

$$T_{BC} = \frac{(2452.50)(3\cos\theta)}{6\sin 67.5°}$$

Again, since the pin at *A* is frictionless and the weight of the brace *AC* is neglected, the brace *AC* is a two-force member and from a free-body diagram of the pin *C*, the equations of equilibrium give



$\rightarrow \Sigma F_x = 0:$

$$F_{AC}\cos(45° + \theta) + T_{BC}\cos(67.5° - \theta) - T_{CD}\cos(22.5° - \theta) = 0$$

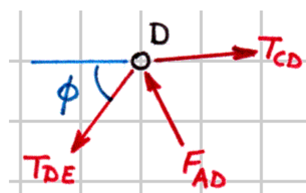
$\uparrow \Sigma F_y = 0:$

$$F_{AC}\sin(45° + \theta) - T_{BC}\sin(67.5° - \theta) + T_{CD}\sin(22.5° - \theta) = 0$$

$$F_{AC} = \frac{\sin(67.5° - \theta)\cos(22.5° - \theta) - \cos(67.5° - \theta)\sin(22.5° - \theta)}{\sin(45° + \theta)\cos(22.5° - \theta) + \cos(45° + \theta)\sin(22.5° - \theta)} T_{BC}$$

$$T_{CD} = \frac{F_{AC}\cos(45° + \theta) + T_{BC}\cos(67.5° - \theta)}{\cos(22.5° - \theta)}$$

Finally, since the weight of the brace *AD* is also neglected, the brace *AD* is also a two-force member and from a free-body diagram of the pin *D*, the equations of equilibrium give



$$\rightarrow \Sigma F_x = 0: \quad -F_{AD}\cos(90° - \theta) + T_{CD}\cos(22.5° - \theta) - T_{DE}\cos\phi = 0$$

$$\uparrow \Sigma F_y = 0: \quad F_{AD}\sin(90° - \theta) - T_{CD}\sin(22.5° - \theta) - T_{DE}\sin\phi = 0$$

$$F_{AD} = \frac{\cos(22.5° - \theta)\sin\phi + \sin(22.5° - \theta)\cos\phi}{\cos(90° - \theta)\sin\phi + \sin(90° - \theta)\cos\phi} T_{CD}$$

$$T_{DE} = \frac{T_{CD}\cos(22.5° - \theta) - F_{AD}\cos(90° - \theta)}{\cos\phi} = P$$

Note that the force in the brace *AD* goes to zero at about $\theta = 75°$. For $75° \le \theta \le 90°$, the solution becomes similar to that of part a (with the angle between the post and the brace *AC* $45°$ rather than $60°$).

For this arrangement, the force P necessary to start raising the post (1700 N) is about 25% less than the force required using a single brace (part a).