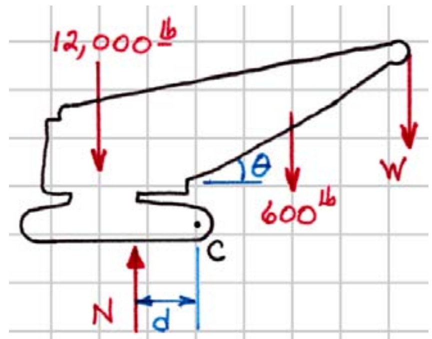
1-51

From an overall free-body diagram of the crane, the equations of equilibrium give



$$\uparrow \Sigma F_y = 0: \qquad N - 12{,}000 - 600 - W = 0$$

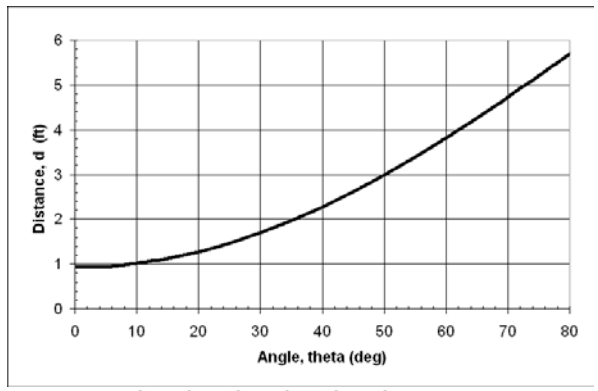
$$\circlearrowleft \Sigma M_C = 0: \quad (9)(12{,}000) - (12\cos\theta - 1)(600) - (24\cos\theta - 1 + 1)W - Nd = 0$$

$$N = (12{,}600 + W)\ \text{lb}$$

$$d = \frac{108{,}600 - (7200 + 24W)\cos\theta}{12{,}600 + W}\ \text{ft}$$

(a) For $W = 3600$ lb

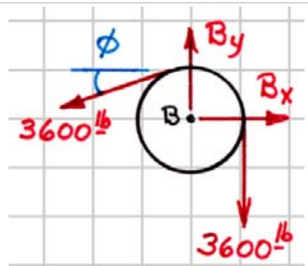
$$d = \frac{108{,}600 - 93{,}600\cos\theta}{16{,}200}\ \text{ft}$$



(b) From a free-body diagram of the pulley at B,

$$\tan\phi = \frac{24\sin\theta - 6}{24\cos\theta + 9}$$

and the equations of equilibrium give

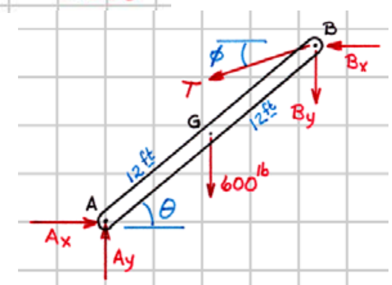


$$\rightarrow \Sigma F_x = 0: \qquad B_x - 3600\cos\phi = 0$$

$$\uparrow \Sigma F_y = 0: \qquad B_y - 3600 - 3600\sin\phi = 0$$

$$B_x = 3600\cos\phi \qquad B_y = 3600(1 + \sin\phi)$$

From a free-body diagram of the boom, the equations of equilibrium give



$$\rightarrow \Sigma F_x = 0: \qquad A_x - B_x - T\cos\phi = 0$$

$$\uparrow \Sigma F_y = 0: \qquad A_y - B_y - T\sin\phi - 600 = 0$$

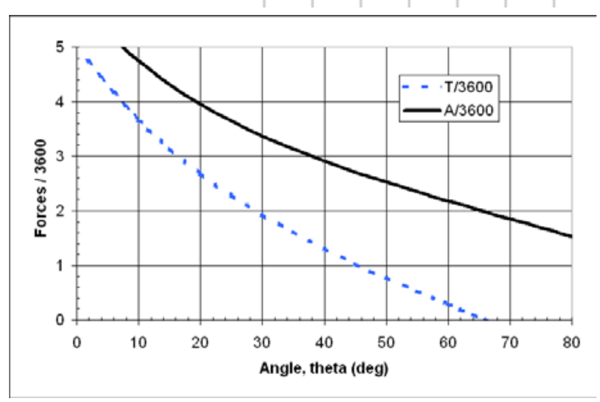
$$\circlearrowleft \Sigma M_A = 0: \quad [24\sin(\theta - \phi)]T - (12\cos\theta)(600) + (24\sin\theta)B_x - (24\cos\theta)B_y = 0$$

$$T = \frac{(7200 + 24B_y)\cos\theta - 24B_x\sin\theta}{24\sin(\theta - \phi)}$$

$$A_x = B_x + T\cos\phi$$

$$A_y = B_y + T\sin\phi + 600$$

$$A = \sqrt{A_x^2 + A_y^2}$$



Note that the tension force becomes negative for an angle of about $66°$. Since negative forces in the cable are not possible, the boom would topple over onto the top of the cab of the crane if the operator tried to lift higher than $66°$.

1-51 (cont.)

(c) For $d = 1$ ft

$$d = \frac{108,600 - \left(7200 + 24W\right)\cos\theta}{12,600 + W} = 1 \text{ ft}$$

$$W_{\max} = \frac{96,000 - 7200\cos\theta}{1 + 24\cos\theta} \text{ lb}$$