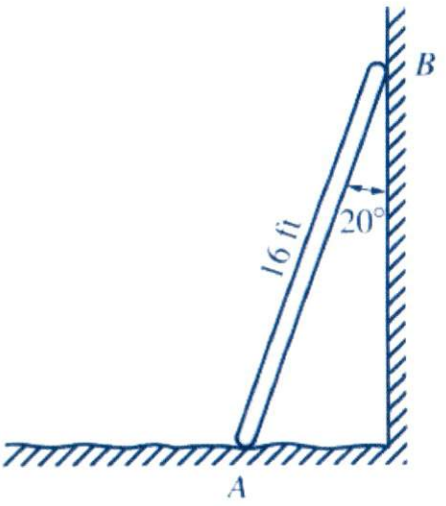
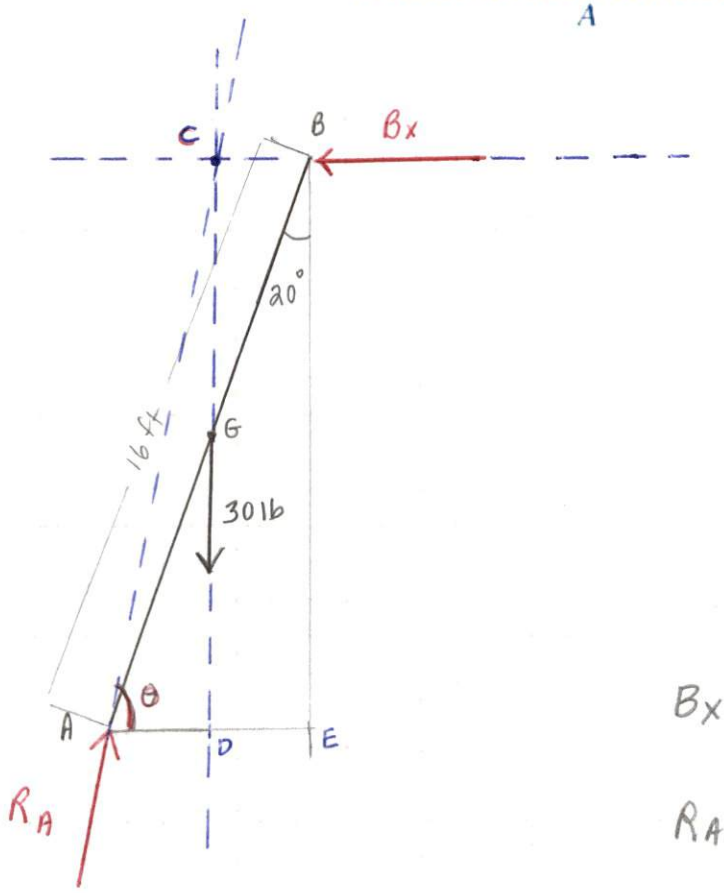
3-31

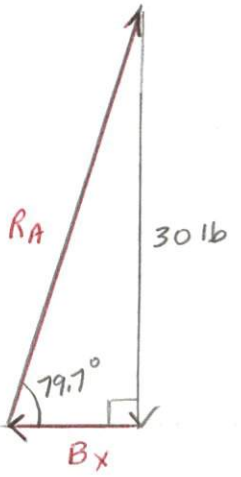
A 30-lb, 16-ft ladder leans against a smooth wall with its lower end resting on a rough ground. See Fig. P3-31. The angle between the ladder and the wall is 20°. Knowing that the ladder will not slip on its lower end, determine the reactions at both ends of the ladder by (a) the force triangle and (b) equilibrium equations.

Solution.



(a) Force-Triangle





Force-Triangle

$$B_x = \frac{30\text{ lb}}{\tan 79.7^\circ} = 5.45\text{ lb} \leftarrow$$

$$R_A = \frac{30\text{ lb}}{\sin 79.7^\circ} = 30.5\text{ lb} \measuredangle 79.7^\circ$$

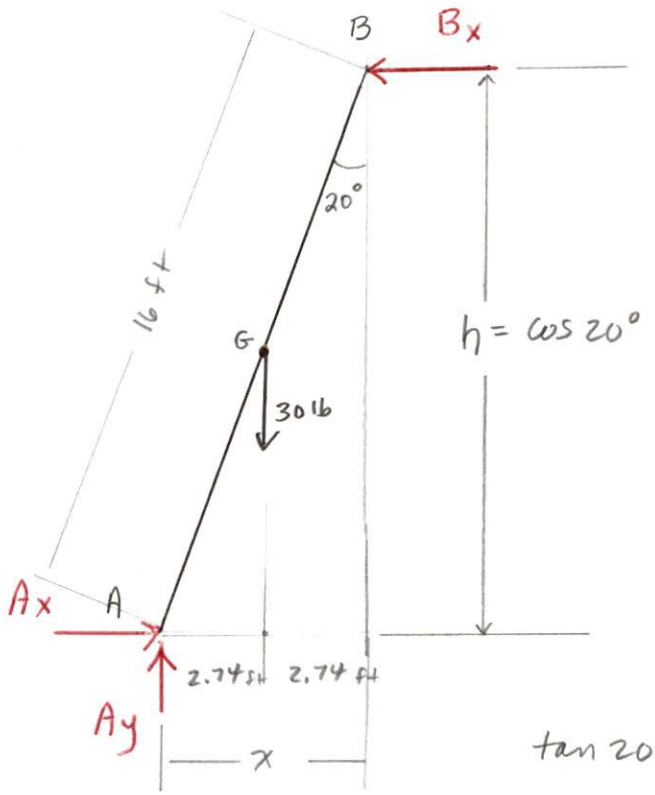
$$\cos 20^\circ = \frac{BE}{16\text{ ft}}$$

$$CD = CE = \cos 20^\circ (16\text{ ft}) = 15.04\text{ ft}$$

$$AD = \frac{1}{2} AE = \frac{1}{2}\sqrt{16\text{ ft}^2 - 15.04\text{ ft}^2} = 2.73\text{ ft}$$

$$\theta = \tan^{-1}\left(\frac{15.04\text{ ft}}{2.73\text{ ft}}\right) = 79.7^\circ$$

(b) Equilibrium Equations



FBD

$\tan 20° = \frac{x}{15.04\,ft}$

$x = \tan 20° (15.04\,ft)$

$= 5.47\,ft$

Equilibrium Equations

ccw +M ↺

cw −M ↻

$[\Sigma M_A = 0] \quad -30\,lb\,(2.74\,ft) + B_x\,(15.04\,ft) = 0$

$B_x = \frac{82.11\ lb.ft}{15.04\,ft} = 5.45\,lb \leftarrow$

$[\Sigma F_x = 0] \quad A_x - B_x = 0$

$A_x = B_x = 5.45\,lb \rightarrow$

$A_x = \underline{5.45}\,lb \rightarrow$

$[\Sigma F_y = 0] \quad A_y - 30\,lb = 0$

$A_y = \underline{30\,lb} \uparrow$