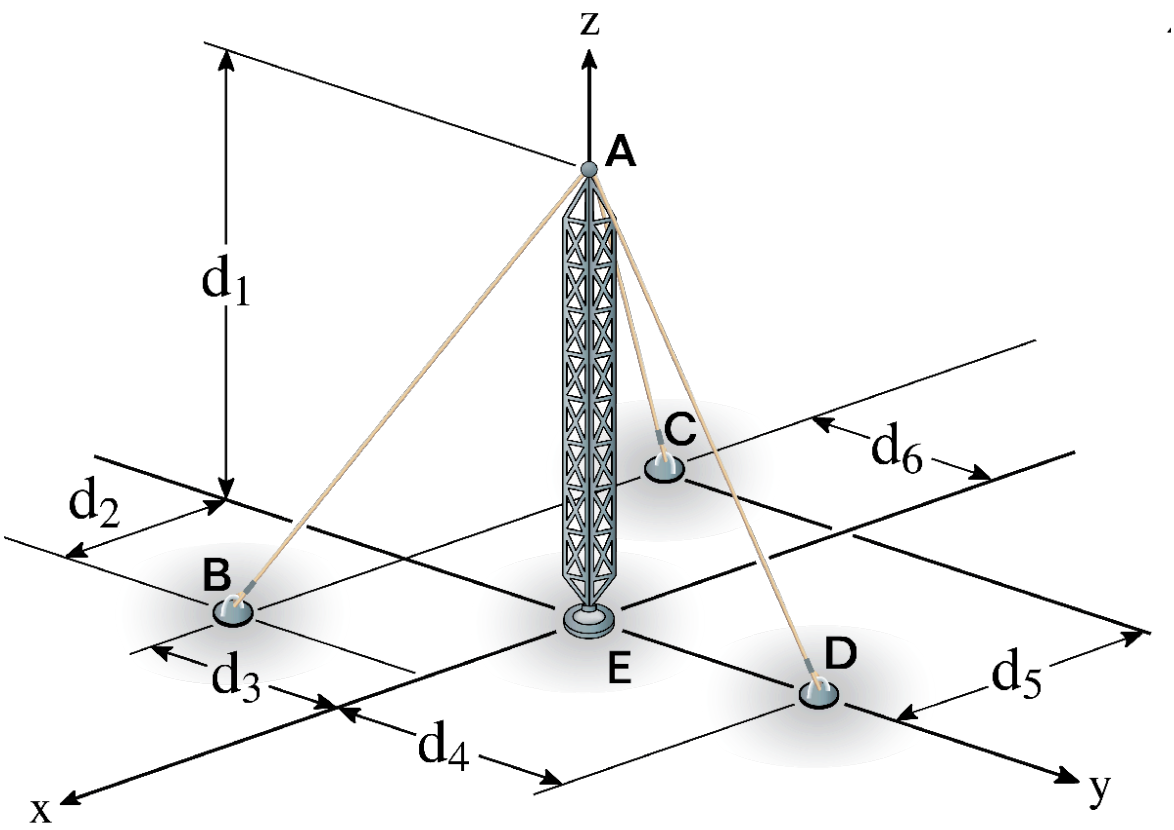
21-S-2.8-RP-06



A metal tower has cables attached to it such that the resultant force has no horizontal component. What is the unit vector that describes the direction of the resultant force?

$$\hat{u}_{F_R} = -\hat{k}$$

If all cables can withstand a tension magnitude of upto F_{max}, determine which cable will have the largest magnitude and the maximum tension in each cable.

$$AB = \sqrt{d_1^2 + d_2^2 + d_3^2}$$

$$AC = \sqrt{d_1^2 + d_5^2 + d_6^2}$$

$$AD = \sqrt{d_1^2 + d_4^2}$$

$$\overrightarrow{F_{AB}} = B \cdot (d_2\hat{i} - d_3\hat{j} - d_1\hat{k})$$

$$B = \frac{F_{AB}}{AB}$$

$$\overrightarrow{F_{AC}} = C \cdot (-d_5\hat{i} - d_6\hat{j} - d_1\hat{k})$$

$$C = \frac{F_{AC}}{AC}$$

$$\overrightarrow{F_{AD}} = D \cdot (d_4\hat{j} - d_1\hat{k})$$

$$D = \frac{F_{AD}}{AD}$$

$$F_{Rx} = \Sigma F_x = 0 \rightarrow B \cdot d_2 - C \cdot d_5 = 0$$

$$\rightarrow B = C \cdot \frac{d_5}{d_2}$$

$$\Rightarrow F_{AB} = \frac{AB}{AC} \cdot \frac{d_5}{d_2} \cdot F_{AC}$$

$$F_{Ry} = \Sigma F_y = 0 \rightarrow -B \cdot d_3 - C \cdot d_6 + D \cdot d_4 = 0$$

$$\rightarrow C \cdot \frac{d_5}{d_2} \cdot d_3 + C \cdot d_6 = D \cdot d_4$$

$$\rightarrow C = D \cdot \frac{d_2 \cdot d_4}{d_3 \cdot d_5 + d_2 \cdot d_6}$$

$$\Rightarrow F_{AC} = \frac{AC}{AD} \cdot \frac{d_2 \cdot d_4}{d_3 \cdot d_5 + d_2 \cdot d_6} \cdot F_{AD}$$

Look at ratios:

$$BC = \frac{F_{AB}}{F_{AC}} = \frac{AB}{AC} \cdot \frac{d_5}{d_2}$$

$$CD = \frac{F_{AC}}{F_{AD}} = \frac{AC}{AD} \cdot \frac{d_2 \cdot d_4}{d_3 \cdot d_5 + d_2 \cdot d_6}$$

$$DB = \frac{1}{BC \cdot CD} = \frac{AD}{AB} \cdot \frac{d_3 \cdot d_5 + d_2 \cdot d_6}{d_5 \cdot d_4}$$

If $BC > 1$:

If $DB < 1$, AB has largest tension

If $DB > 1$, AD has largest tension

Else, if $BC < 1$:

If $CD > 1$, AC has largest tension

If $CD < 1$, AD has largest tension

To find max tension magnitudes, let the cable with the largest tension be equal to F_{max}. Use BC, CD, and DB to find the relationships between the cable tensions.