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Thursday, January 18, 2024 1:42 PM

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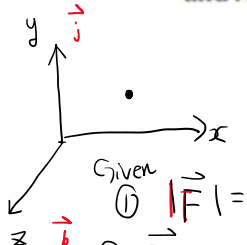
• 3D Force

○ **Problem 1** Suppose that you want to apply a 1000-lb force **F** at point *A* in a direction such that the resulting tensions in cables *AB*, *AC*, and *AD* are equal. Determine the components of **F**.



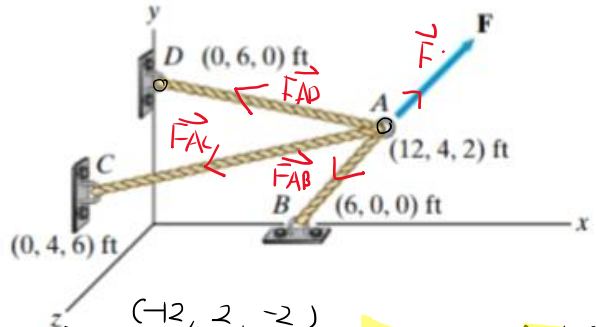
$\vec{V} = V_x\vec{i} + V_y\vec{j} + V_z\vec{k}$

$\vec{V} = (V_x, V_y, V_z)$

Given ① $|\vec{F}| = 1000\,lb$ ←

② $\vec{e}_{AD}$, $\vec{e}_{AC}$, $\vec{e}_{AB}$ from geometry ←

unit vectors



$\vec{e}_{AD} = \frac{\vec{AD}}{|\vec{AD}|} = \frac{(0,6,0)-(12,4,2)}{|(0,6,0)-(12,4,2)|} = \frac{(-12,2,-2)}{\sqrt{(-12)^2+2^2+(-2)^2}} = (-0.9733,\ 0.1622,\ -0.1622)$

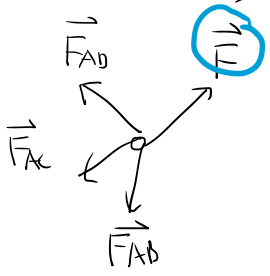
$\vec{e}_{AC} = \frac{\vec{AC}}{|\vec{AC}|} = (-0.9487,\ 0,\ 0.3162)$

$\vec{e}_{AB} = \frac{\vec{AB}}{|\vec{AB}|} = (-0.8018,\ 0.5345,\ -0.2673)$

$\vec{F}_{AD} = |\vec{F}_{AD}|\,\vec{e}_{AD} = F_0\,\vec{e}_{AD}$

$\vec{F}_{AC} = |\vec{F}_{AC}|\,\vec{e}_{AC} = F_0\,\vec{e}_{AC}$

$\vec{F}_{AB} = |\vec{F}_{AB}|\,\vec{e}_{AB} = F_0\,\vec{e}_{AB}$



F_0 : unknown

$\vec{e}_F = (n_x, n_y, n_z)$

$\vec{F} = |\vec{F}|\,\vec{e}_F = |\vec{F}|\,(n_x, n_y, n_z)$ → 3 unknowns

$|\vec{F}| = 1000\,lb$ unknown

We need to have 4 equations to solve 4 unknowns: F_0, n_x, n_y, n_z

$\sum_{i=1}^{4} F_{xi} = 0 \Rightarrow F_{ADx} + F_{ACx} + F_{ABx} + F_x = 0$

x direction: $-0.9733F_0 - 0.9487F_0 - 0.8018F_0 + 1000n_x = 0$ } From

$$\begin{cases} \text{x direction: } -0.973\,F_0 - 0.487\,F_0 - 0.8018\,F_0 + 1000\,n_x = 0 \\ \text{y direction: } 0.1622\,F_0 - 0.5345\,F_0 + 1000\,n_y = 0 \\ \text{z direction: } -0.1622\,F_0 + 0.8162\,F_0 - 0.2673\,F_0 + 1000\,n_z = 0 \end{cases} \quad \text{From equilibrium}$$

$$n_x^2 + n_y^2 + n_z^2 = 1 \quad \text{unit vector definition}$$

4 eq. for 4 unknowns ✓

$+2 \cdot .7238\,F_0 = 1000\,n_x$

$F_0 = 363.4443$ lb