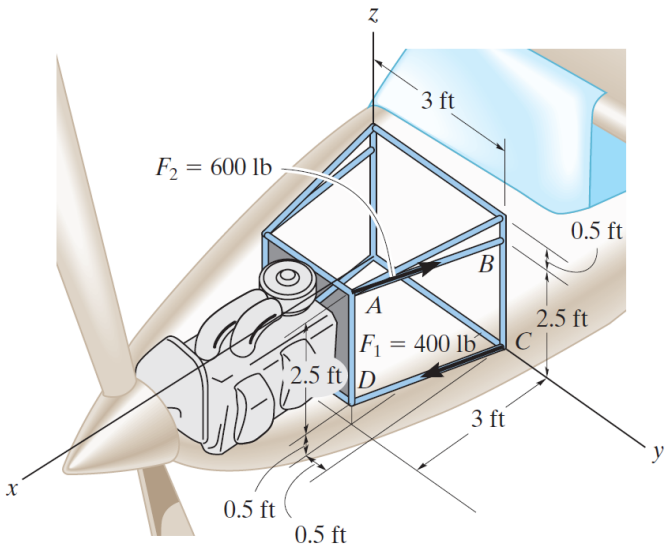
Problem 2-102

The engine of the lightweight plane is supported by struts that are connected to the space truss that makes up the structure of the plane. The anticipated loading in two of the struts is shown. Express each of those forces as Cartesian vector.



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[TYPO: This should be "as a Cartesian vector."]

Solution

Write the position vectors to the points A, B, C, and D.

$$\mathbf{r}_A = \langle 3, 2.5, 3 \rangle \text{ ft}$$

$$\mathbf{r}_B = \langle 0, 3, 2.5 \rangle \text{ ft}$$

$$\mathbf{r}_C = \langle 0, 3, 0 \rangle \text{ ft}$$

$$\mathbf{r}_D = \langle 3, 2.5, 0.5 \rangle \text{ ft}$$

The position vector going from A to B is

$$\begin{aligned}\mathbf{r}_{AB} &= \mathbf{r}_B - \mathbf{r}_A \\ &= \langle -3, 0.5, -0.5 \rangle \text{ ft}.\end{aligned}$$

Its magnitude is

$$\begin{aligned}|\mathbf{r}_{AB}| &= \sqrt{(-3)^2 + (0.5)^2 + (-0.5)^2} \text{ ft} \\ &= \sqrt{\frac{19}{2}} \text{ ft}.\end{aligned}$$

Divide $\mathbf{r}_{AB}$ by its magnitude to get a unit vector in the same direction.

$$\hat{\mathbf{u}}_{AB} = \frac{\mathbf{r}_{AB}}{|\mathbf{r}_{AB}|} = \frac{\langle -3, 0.5, -0.5 \rangle}{\sqrt{\frac{19}{2}}}$$

The force $\mathbf{F}_2$ can now be written.

$$\mathbf{F}_2 = F_2 \hat{\mathbf{u}}_{AB} = 600 \, \frac{\langle -3, 0.5, -0.5 \rangle}{\sqrt{\frac{19}{2}}} \text{ lb} \approx \langle -584, 97.3, -97.3 \rangle \text{ lb}$$

On the other hand, the position vector going from C to D is

$$\begin{aligned} \mathbf{r}_{CD} &= \mathbf{r}_D - \mathbf{r}_C \\ &= \langle 3, -0.5, 0.5 \rangle \text{ ft}. \end{aligned}$$

Its magnitude is

$$\begin{aligned} |\mathbf{r}_{CD}| &= \sqrt{(3)^2 + (-0.5)^2 + (0.5)^2} \text{ ft} \\ &= \sqrt{\frac{19}{2}} \text{ ft} \, . \end{aligned}$$

Divide $\mathbf{r}_{CD}$ by its magnitude to get a unit vector in the same direction.

$$\hat{\mathbf{u}}_{CD} = \frac{\mathbf{r}_{CD}}{|\mathbf{r}_{CD}|} = \frac{\langle 3, -0.5, 0.5 \rangle}{\sqrt{\frac{19}{2}}}$$

The force $\mathbf{F}_1$ can now be written.

$$\mathbf{F}_1 = F_1 \hat{\mathbf{u}}_{CD} = 400 \, \frac{\langle 3, -0.5, 0.5 \rangle}{\sqrt{\frac{19}{2}}} \text{ lb} \approx \langle 389, -64.9, 64.9 \rangle \text{ lb}$$