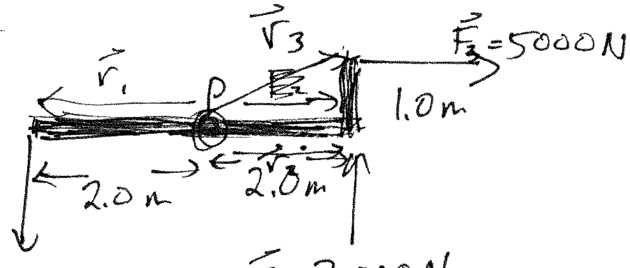
Chapter 12 — Problem 28

Is it possible to apply a force at P to keep the structure in equilibrium?



Assume a force does exist, $F_1 = 2000\,N$ $\quad F_2 = 3000\,N$

Then there will be an x + y component. ~~For~~ Treat them as two independent variables

Use $\sum \vec{F} = 0$, then in the

x-direction $\quad 5000 + F_x = 0 \quad \therefore F_x = -5000\,N$

y-direction $\quad 3000 - 2000 + F_y = 0 \quad \therefore F_y = 1000\,N$

Does this result in rotational equilibrium?

~~This~~ If equilibrium exists, then it will be in rotational equilibrium regardless of the choice of pivot point.

Let's chose P as the pivot point, then

$\cancel{\sum \vec{\tau} = r_1 F_1 \sin\theta_1 + r_2 F_2 \sin\theta_2 + r_3 F_3 \sin\theta_3}$

$$\sum \vec{\tau} = \vec{r}_1 \times \vec{F}_1 + \vec{r}_2 \times \vec{F}_2 + \vec{r}_3 \times \vec{F}_3$$

$$= (-2.0\,\hat{i}) \times (-2000\,\hat{j}) + (+2.0\,\hat{i}) \times (+3000\,\hat{j}) + (2.0\,\hat{i} + 1.0\,\hat{j}) \times (+5000\,\hat{i})$$

$$= 4{,}000\,(\hat{i} \times \hat{j}) + 6{,}000\,(\hat{i} \times \hat{j}) + 10{,}000\,(\hat{i} \times \hat{i}) + 5{,}000\,(\hat{j} \times \hat{i})$$

$$= 4{,}000\,\hat{k} + 6{,}000\,\hat{k} + 0 - 5{,}000\,\hat{k}$$

$$= 5000\,\hat{k}$$

$$\boxed{\sum \vec{\tau} \neq 0 \quad \therefore \text{There is no force applied to P that can achive equilibrium.}}$$

Alternate pivot (use left end)

$$\sum \vec{\tau} = 0 \cdot \vec{F}_1 + (2\,\hat{i}) \times (\underbrace{-5000\,\hat{i} + 1000\,\hat{j}}_{F_x\hat{i} + F_y\hat{j}}) + (4\,\hat{i}) \times (3000\,\hat{j}) + (4\,\hat{i} + 1\,\hat{j})(5000\,\hat{i})$$

$$\sum \vec{\tau} = 0 - 10{,}000\,(\hat{i} \times \hat{i}) + 2000\,(\hat{i} \times \hat{j}) + 12{,}000\,(\hat{i} \times \hat{j}) + 20{,}000\,\hat{i} \times \hat{i} + 5000\,(\hat{j} \times \hat{i})$$

$$\sum \vec{\tau} = 0 + 0 + 2000\,\hat{k} + 12{,}000\,\hat{k} + 0 - 5000\,\hat{k} = 9{,}000\,\hat{k} \neq 0$$

(No static equilibrium)