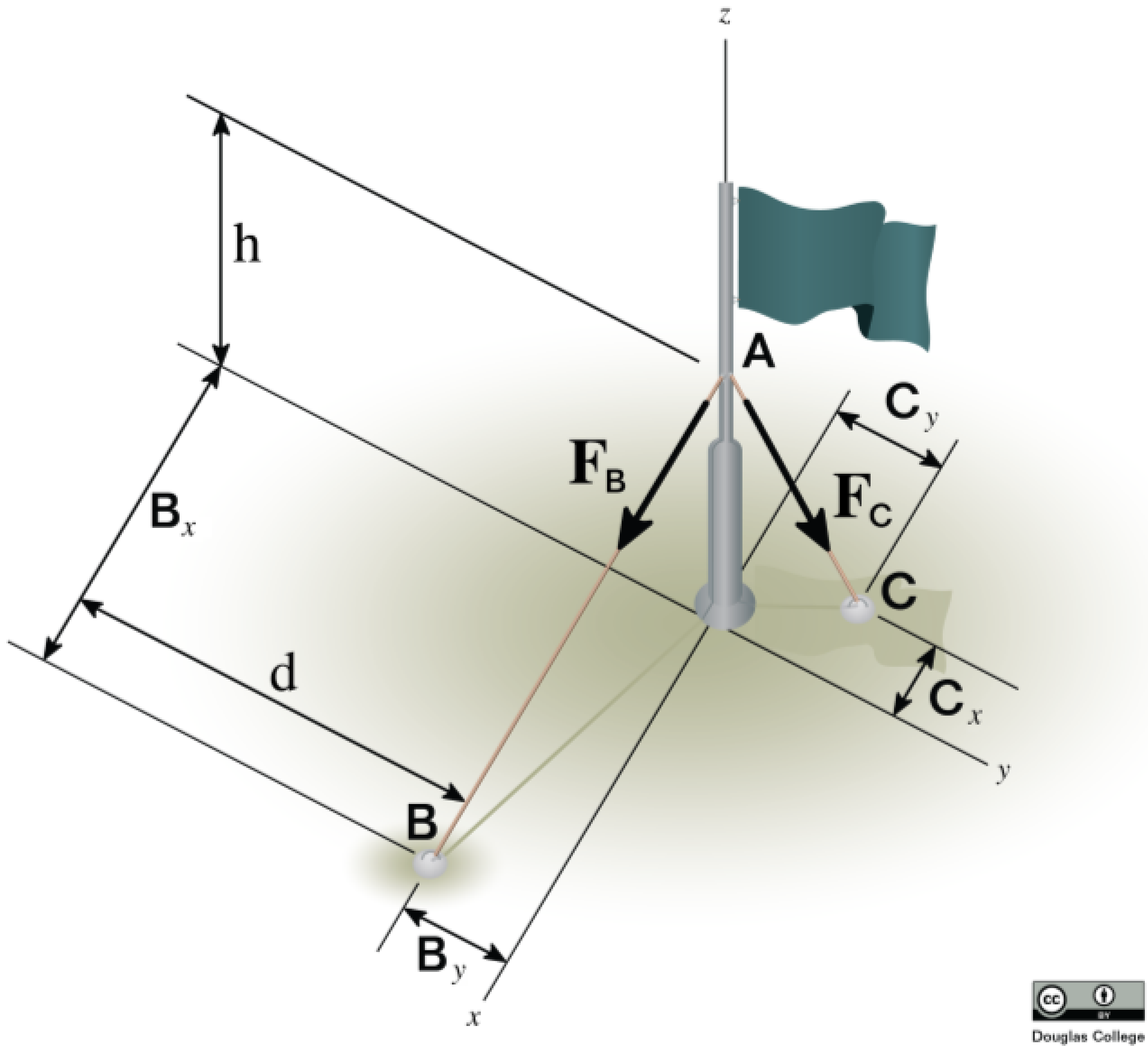
21-5-4-3-GD-002

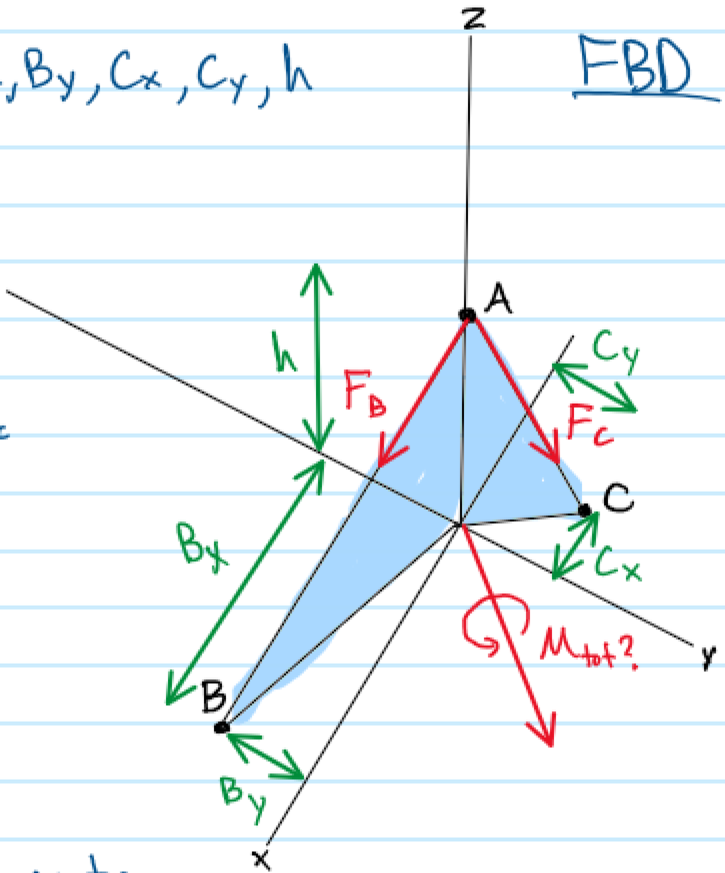


The flagpole shown is tied down with two separate ropes B and C. What is the moment produced by $F_B = F_B$ N and $F_c = F_c$ N about the base of the pole?

($B_x = B_x$ m, $B_y = B_y$ m, $C_x = C_x$ m, $C_y = C_y$ m, and $h = h$ m) given $F_B, F_C, B_x, B_y, C_x, C_y, h$

find M_{tot}

FBD



either r_A or r_B and r_C can be used to solve for the moments

F_B as a Cartesian vector

$$\vec{F}_B = F_B u_{AB} = F_B\left[\frac{B_x}{r_{AB}}\hat{i} - \frac{B_y}{r_{AB}}\hat{j} - \frac{h}{r_{AB}}\hat{k}\right] = F_B\left[\frac{(B_x\hat{i} - B_y\hat{j} - h\hat{k})}{\sqrt{B_x^2 + B_y^2 + h^2}}\right]$$

$$\vec{F}_B = \underbrace{\frac{F_B B_x}{r_{AB}}}_{F_{Bx}}\hat{i} - \underbrace{\frac{F_B B_y}{r_{AB}}}_{F_{By}}\hat{j} - \underbrace{\frac{F_B h}{r_{AB}}}_{F_{Bz}}\hat{k}$$

F_C as a Cartesian Vector

$$\vec{F}_C = F_C u_{AC} = F_C\left[\frac{-C_x}{r_{AC}}\hat{i} + \frac{C_y}{r_{AC}}\hat{j} - \frac{h}{r_{AC}}\hat{k}\right] = F_C\left[\frac{(C_x\hat{i} + C_y\hat{j} - h\hat{k})}{\sqrt{C_x^2 + C_y^2 + h^2}}\right]$$

$$\vec{F}_C = \underbrace{\frac{-F_C C_x}{r_{AC}}}_{F_{Cx}}\hat{i} + \underbrace{\frac{F_C C_y}{r_{AC}}}_{F_{Cy}}\hat{j} - \underbrace{\frac{F_C h}{r_{AC}}}_{F_{Cz}}\hat{k}$$

Moments from $\vec{r} \times \vec{F}$

$$
B\left\{
\begin{array}{l}
\vec{M}_B = \vec{r}_A \times \vec{F}_B = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 0 & 0 & h \\ F_{Bx} & F_{By} & F_{Bz} \end{vmatrix} \\[2em]
\vec{M}_B = (0\cdot\cancel{F_{Bz}} - h\cdot F_{By})\hat{\imath} + (h\cdot F_{Bx} - 0\cdot\cancel{F_{Bz}})\hat{\jmath} + (\cancel{0\cdot F_{By}} - \cancel{0\cdot F_{Bx}})\hat{k} \\[2em]
\vec{M}_B = \overbrace{(-h\cdot F_{By})}^{M_{Bx}}\hat{\imath} + \overbrace{(h\cdot F_{Bx})}^{M_{By}}\hat{\jmath} + \overbrace{(0)}^{M_{Bz}}\hat{k} \ \ N\cdot m
\end{array}
\right.
$$

$$
C\left\{
\begin{array}{l}
\vec{M}_C = \vec{r}_A \times \vec{F}_C = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 0 & 0 & h \\ F_{Cx} & F_{Cy} & F_{Cz} \end{vmatrix} \\[2em]
\vec{M}_C = (0\cdot\cancel{F_{Cz}} - h\cdot F_{Cy})\hat{\imath} + (h\cdot F_{Cx} - 0\cdot\cancel{F_{Cz}})\hat{\jmath} + (\cancel{0\cdot F_{Cy}} - \cancel{0\cdot F_{Cx}})\hat{k} \\[2em]
\vec{M}_C = \overbrace{(-h\cdot F_{Cy})}^{M_{Cx}}\hat{\imath} + \overbrace{(h\cdot F_{Cx})}^{M_{Cy}}\hat{\jmath} + \overbrace{(0)}^{M_{Cz}}\hat{k} \ \ N\cdot m
\end{array}
\right.
$$

Total Moment

$$M_{tot} = (M_{Bx} + M_{Cx})\hat{\imath} + (M_{By} + M_{Cy})\hat{\jmath} + (0)\hat{k}$$