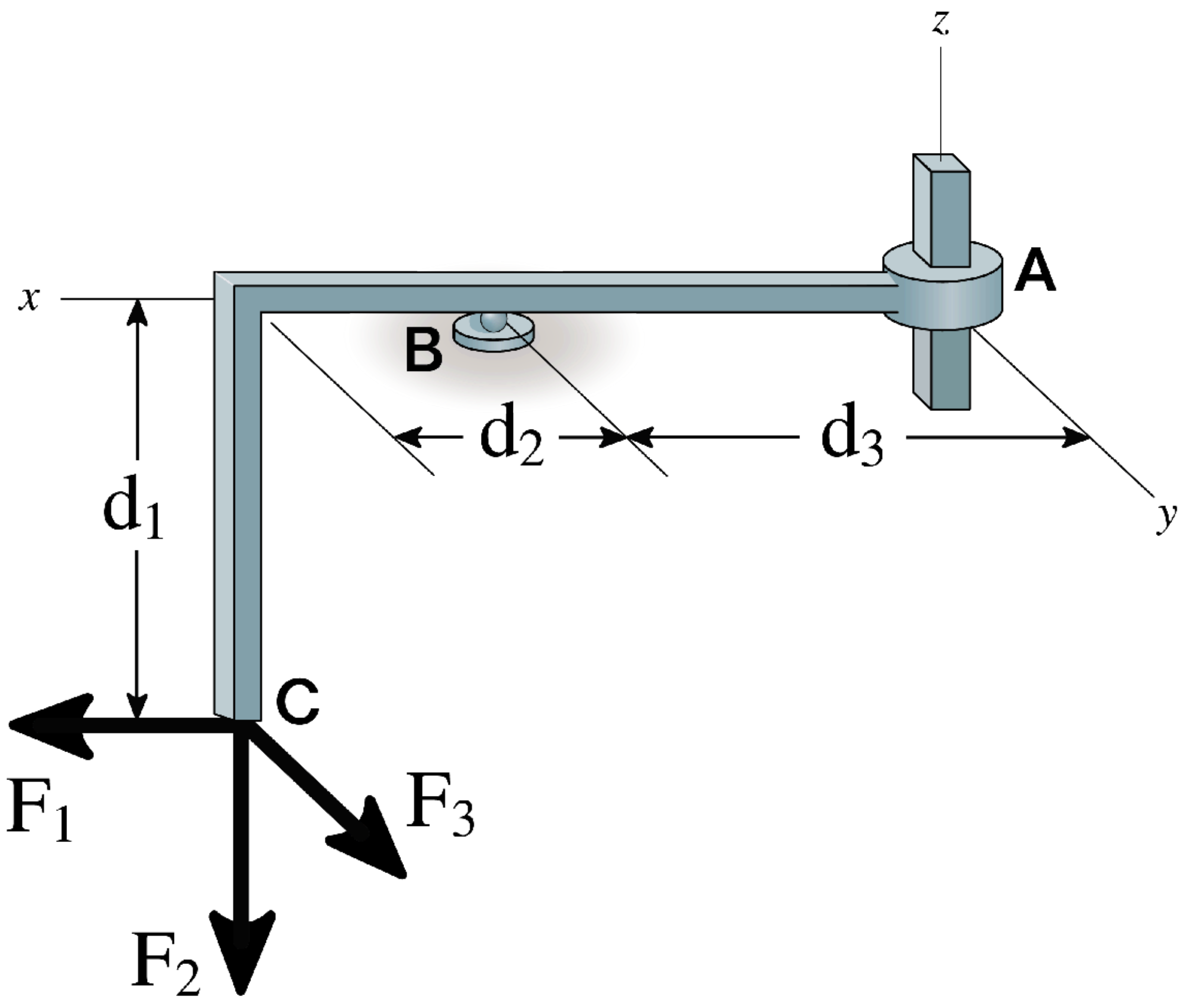




The metal member is held in equilibrium. The member is supported by a square bar fitted through a smooth square hole of the attached collar at point $A$ and by a roller at point $B$. If the roller at $B$ can support a maximum normal force of $N_{B_{max}}$ and the maximum allowable magnitude of the moment created at $A$ is $M_{A_{max}}$, find the largest possible magnitude of the force $F_C$ that is the resultant of $F_1$, $F_2$, and $F_3$. Ignore the mass of the member.

$$\Sigma F_z = 0 \rightarrow N_B - F_2 = 0 \rightarrow N_B = F_2 \rightarrow F_{2_{max}} = N_{B_{max}}$$

$$\Sigma(M_y)_A = 0 \rightarrow (M_A)_y + d_2 \cdot F_2 - d_1 \cdot F_1 = 0 \rightarrow (M_A)_y = d_1 \cdot F_1 - d_2 \cdot F_2$$

$$\Sigma(M_x)_A = 0 \rightarrow (M_A)_x + d_1 \cdot F_3 = 0 \rightarrow (M_A)_x = -d_1 \cdot F_3$$

$$\Sigma(M_z)_A = 0 \rightarrow (M_A)_z + (d_2 + d_3) \cdot F_3 = 0 \rightarrow (M_A)_z = -(d_2 + d_3) \cdot F_3$$

$M_A = \sqrt{(M_A)_x{}^2 + (M_A)_y{}^2 + (M_A)_z{}^2}$

To minimize $M_A$ while maximizing $F_C$, let $(M_A)_y = d_1 \cdot F_1 - d_2 \cdot F_2 = 0 \rightarrow F_1 = \dfrac{d_2}{d_1}F_2$

To maximize $F_C$, let $F_{2_{max}} = N_{B_{max}} \rightarrow F_{1_{max}} = \dfrac{d_2}{d_1}N_{B_{max}}$

Since $(M_A)_y = 0$, $M_A = \sqrt{(M_A)_x{}^2 + (M_A)_z{}^2} = \sqrt{(-d_1 \cdot F_3)^2 + (-(d_2 + d_3) \cdot F_3)^2} = F_3 \sqrt{d_1{}^2 + d_2{}^2 + 2(d_2 \cdot d_3) + d_3{}^2}$

$\rightarrow F_{3_{max}} = \dfrac{M_{A_{max}}}{\sqrt{d_1{}^2 + d_2{}^2 + 2(d_2 \cdot d_3) + d_3{}^2}}$

$F_{C_{max}} = \sqrt{F_{1_{max}}{}^2 + F_{2_{max}}{}^2 + F_{3_{max}}{}^2}$