Example 9.1

Problem 1

Determine the total moment about point A due to the three forces acting on the L-shaped structure.

\[ \sum M_A = - (250 \cos 30^\circ)(2) - (300 \cos 60^\circ)(5) \]
\[ - (500 \cos 45^\circ)(7) + (500 \cos 37.5^\circ)(4) \]
\[ = -333.8 \text{ N.m} \]
Example 9.2

Problem 2

Two boys push on the gate as shown. If the boy at B exerts a force of \( F_B = 30 \text{ lb} \), determine the magnitude of the force \( F_A \) the boy at A must exert in order to prevent the gate from turning. Neglect the thickness of the gate.

Sum moments about point C and solve for case where:

\[ \sum M_C = 0 \]

\[ \sum M_C = -[F_A (3/2)] (4) + (F_B \sin 60^\circ) (6) = 0 \]

With \( F_B = 30 \text{ lb} \):

\[ F_A = \frac{5}{3} \left( \frac{30 \sin 60^\circ}{4} \right) 6 \]

\[ F_A = 28.9 \text{ lb} \]
Example 9.3

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Problem 3

The tower crane is used to hoist a 2-Mg load upward at constant velocity. The 1.5-Mg jib BD and 0.5-Mg jib BC have centers of mass at $G_1$ and $G_2$, respectively. Determine the required mass of the counterweight $C$ so that the resultant moment produced by the load and the weight of the tower crane jibs about point A is zero. The center of mass for the counterweight is located at $G_2$.

All forces are parallel to line AB so

$$
\sum F_x = \sum M_A = \sum M_B
$$

1) $\sum F_B = + F_{G_3}(7.5) + F_{G_2}(4) - F_{G_1}(9.5) - W(12.5)$

$$
F_{G_2} = \frac{m_0 g}{4}
$$

$$
F_{G_2} = (0.5 \text{ Mg}) \frac{g}{4}
$$

$$
F_{G_1} = (1.5 \text{ Mg}) \frac{g}{4}
$$

$$
W = (2 \text{ Mg}) g
$$

Note $m_0 = 10^6 g = 10^3 \text{ kg}$

$I = 9.81 \text{ m}^2$.

Setting $\sum M_B = 0$ and solving for $m_C$

$$
m_C = \frac{(1.5)(9.5) + (2)(12.5) - (0.5)(4)}{7.5}
$$

$$
m_C = 4.97 \text{ Mg}
$$
Example 9.4

Problem 4

The connected bar BC is used to increase the lever arm of the crescent wrench as shown. If a clockwise moment of $M_c = 120 \text{ N} \cdot \text{m}$ is needed to tighten the nut at A and the extension $d = 300 \text{ mm}$, determine the required force $F$ in order to develop this moment.

\[ F = \frac{120}{0.3 \sin 45^\circ (1 + 0.3 \cos 30^\circ) + 0.3 \cos 45^\circ \sin 45^\circ} \]

\[ F = 207 \text{ N} \]
Example 3D moment

Position Vector \( \vec{r} \) from \( P \) (the point of interest) to the point of application of the force, \( \vec{F} \) is

\[
\vec{r} = 5\hat{i} + 4\hat{j} - 1\hat{k}
\]

Point \( P \) is \((-4, 2, 3)\)

Location of force \( D \) is \((1, -2, 2)\)

\[
\vec{F} = [1 - (-4)i]\hat{i} + [-2 - 2]\hat{j} + [2 - 3]k
\]

\[
= 5\hat{i} - 4\hat{j} - 1\hat{k}
\]

\[
\overline{M}_P = \vec{r} \times \vec{F}
\]

\[
= \left( 5\hat{i} - 4\hat{j} - 1\hat{k} \right) \times \left( -2\hat{i} + 3\hat{j} + 4\hat{k} \right)
\]

\[
= (-4)(4\hat{i} + 3\hat{j} + 6\hat{k}) + (-1)(-4\hat{i} + 4\hat{j} + 4\hat{k}) + (1)(3\hat{i} + 2\hat{j} + \hat{k})
\]

\[
= (16\hat{i} + 12\hat{j} + 6\hat{k}) - (4\hat{i} - 4\hat{j} - 4\hat{k}) + (3\hat{i} + 2\hat{j} + \hat{k})
\]

\[
= 16\hat{i} + 16\hat{j} + 7\hat{k}
\]

\[
= 16\hat{i} + 16\hat{j} + 7\hat{k}
\]

\[
= (-16 + 16)\hat{i} + (-20 + 20)\hat{j} + (15 - 8)\hat{k}
\]

\[
\overline{M}_P = -18\hat{i} - 18\hat{j} + 7\hat{k}
\]
The magnitude of the moment is

\[ M_p = \sqrt{18^2 + 14^2 + 3^2} = 23.3 \text{ kN\cdot m} \]