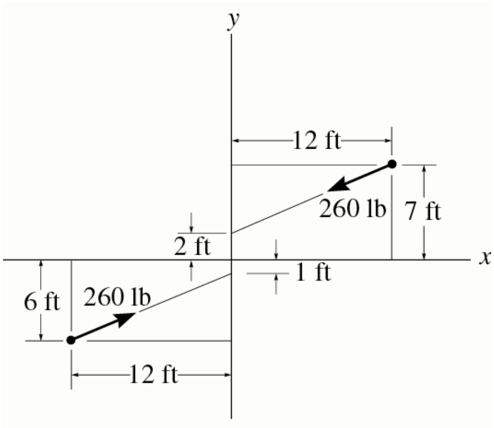
Moment 4:

Problem 1:

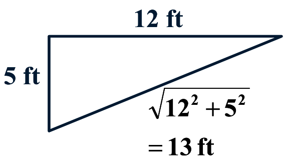
Determine the magnitude and sense of the couple moment shown in the figure.

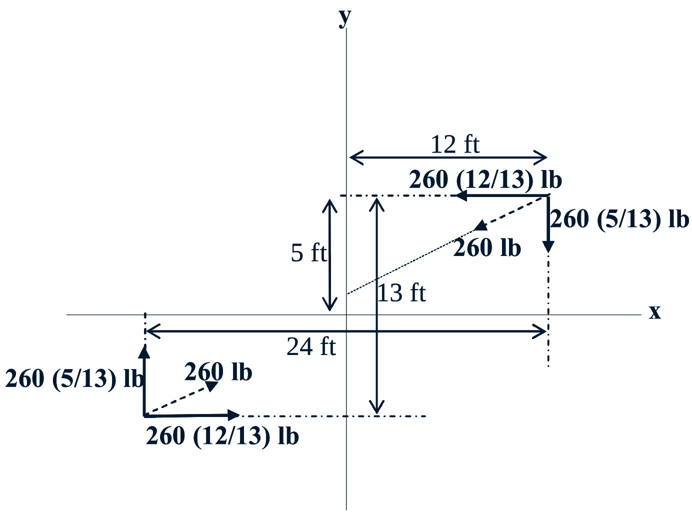


Solution:

$$\circlearrowleft + M_C = 260\left(\frac{12}{13}\right)(13) - 260\left(\frac{5}{13}\right)(24)$$

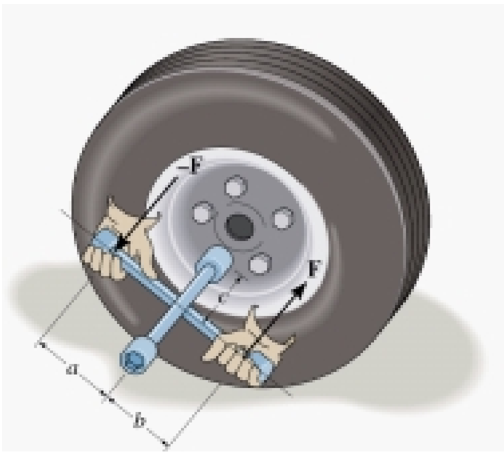
$$\Rightarrow M_C = 720\,\text{lb.ft (couterclockwise)}$$





Problem 2 (Moment of a couple):

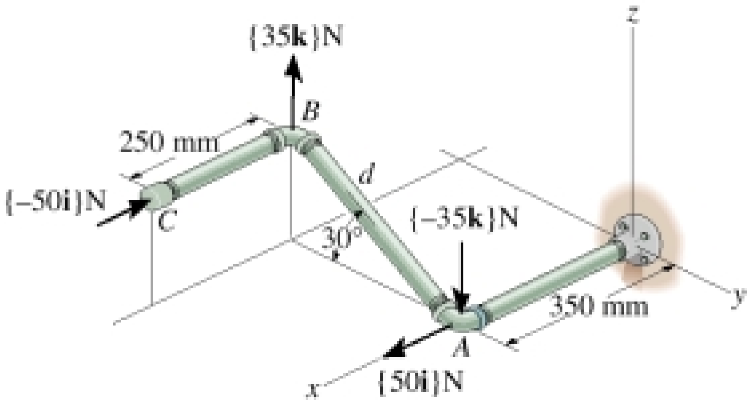
The crossbar wrench is used to remove a lug nut from the automobile wheel. The mechanic applies a moment couple to the wrench such that his hands are a constant distance apart. Is it necessary that a = b in order to produce the most effective turning of the nut? Explain.
Also what is the effect of changing the shaft dimension c in this regard? The forces act in the vertical plane.



Solution:
Couple moment: $M_c = F(a+b)$,
The couple moment depends on the total distance between grips. a=b is not a necessary condition to produce the most effective turning of the nut. Changing the dimension c has no effect on turning the nut.

Problem 3:

Determine the resultant couple moment of the two couples that act on the pipe assembly. The distance from A to B is d = 400 mm. Express the result as a Cartesian vector.



Solution:

Position Vector :

A(0.35, 0, 0)

B(0.35, -0.4cos30°,0.4 sin30°)

$$r_{AB} = \{(0.35 - 0.35)i + (-0.4\cos 30° - 0)\,j + (0.4\sin 30° - 0)\,k\}\,m$$
$$\Rightarrow r_{AB} = \{-0.35\,j + 0.2\,k\}\,m$$

Couple Moments :

$$\mathbf{r_{AB}} = \{-0.35\,\mathbf{j} + 0.2\,\mathbf{k}\}\,m$$
$$\mathbf{F_1} = \{35\mathbf{k}\}\ N; \qquad \mathbf{F_2} = \{-50\mathbf{i}\}\ N$$
$$(\mathbf{M_C})_1 = \mathbf{r_{AB}} \times \mathbf{F_1}$$
$$\Rightarrow (\mathbf{M_C})_1 = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0 & -0.35 & 0.2 \\ 0 & 0 & 35 \end{vmatrix} = \{-12.25\,\mathbf{i}\}\,N.m$$
$$(\mathbf{M_C})_2 = \mathbf{r_{AB}} \times \mathbf{F_2}$$
$$\Rightarrow (\mathbf{M_C})_2 = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0 & -0.35 & 0.2 \\ -50 & 0 & 0 \end{vmatrix} = \{-10\,\mathbf{j} - 17.5\,\mathbf{k}\}\,N.m$$
$$\mathbf{r_{AB}} = \{-0.35\,\mathbf{j} + 0.2\,\mathbf{k}\}\,m$$
$$\mathbf{F_1} = \{35\mathbf{k}\}\ N; \qquad \mathbf{F_2} = \{-50\mathbf{i}\}\ N$$
$$(\mathbf{M_C})_1 = \{-12.25\,\mathbf{i}\}\,N.m$$
$$(\mathbf{M_C})_2 = \{-10\,\mathbf{j} - 17.5\,\mathbf{k}\}\,N.m$$

Resultant Couple Moment :

$$\mathbf{M_R} = \Sigma\mathbf{M}$$
$$\Rightarrow \mathbf{M_R} = (\mathbf{M_C})_1 + (\mathbf{M_C})_2 = \{-12.25\,\mathbf{i} - 10\,\mathbf{j} - 17.5\,\mathbf{k}\}\,N.m$$

Scalar Analysis: Summing moments about x, y, and z axes

$$\left(M_R\right)_x = \Sigma M_x = -35(0.4\cos 30°)$$

$$\Rightarrow \left(M_R\right)_x = -12.25 \text{ N.m}$$

$$\left(M_R\right)_y = \Sigma M_y = -50(0.4\sin 30°)$$

$$\Rightarrow \left(M_R\right)_y = -10 \text{ N.m}$$

$$\left(M_R\right)_z = \Sigma M_z = -50(0.4\cos 30°)$$

$$\Rightarrow \left(M_R\right)_z = -17.5 \text{ N.m}$$

Express M_R as a Cartesian vector:

$$\Rightarrow \mathbf{M_R} = \left\{-12.25\,\mathbf{i} - 10\,\mathbf{j} - 17.5\,\mathbf{k}\right\} \text{N.m}$$