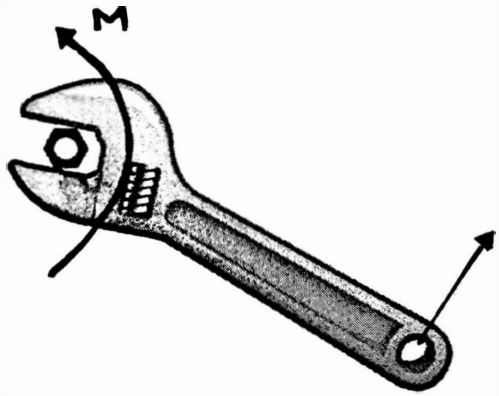
Name: _____
Group members: _____ _____ _____

TAM 210/211 - Worksheet 5

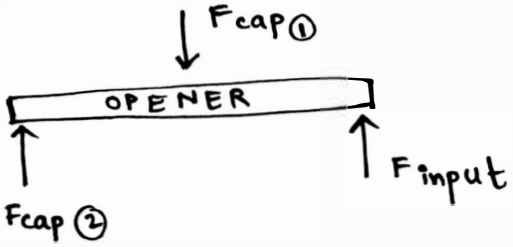
Objectives:

- Evaluate moments in 2D and 3D problems
- Obtain resultant forces and moments for equivalent systems.

1) Draw the forces and resulting moment that acts on a wrench when unfastening a nut.



2) Sketch a diagram of the forces and moments acting on a bottle opener.



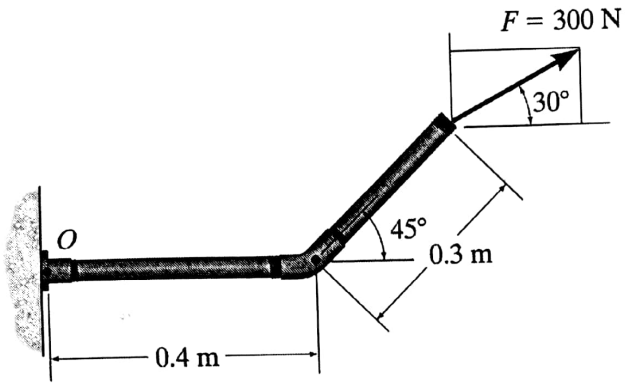


Figure 1

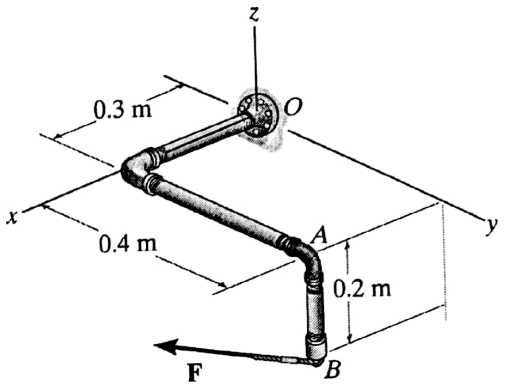


Figure 2

3) Use Figure 1 to determine the moment of the force about point O using the scalar formulation.

$$\Sigma M = [300 \sin 30^\circ][0.4 + 0.3 \cos 45^\circ] - [300 \cos 30^\circ][0.3 \sin 45^\circ]$$

$$\boxed{\Sigma M = 36.71 \text{ N-m}}$$

4) Use Figure 2 and the force $\mathbf{F} = 300\mathbf{i} - 200\mathbf{j} + 150\mathbf{k}$ to determine: (a) the moment of the force about point O using the vector formulation, and (b) the moment of the same force about the x-axis.

a) $\vec{r} = \langle 0.3, 0.4, -0.2 \rangle$ $\quad \vec{F} = \langle 300, -200, 150 \rangle$

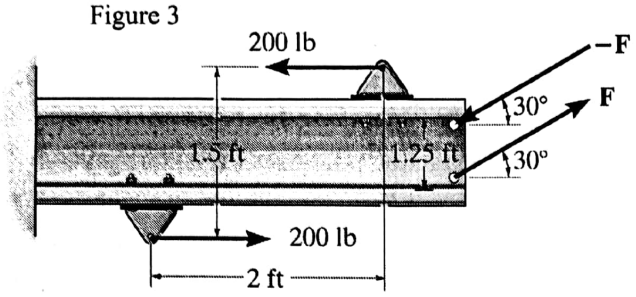
$$\vec{M} = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0.3 & 0.4 & -0.2 \\ 300 & -200 & 150 \end{vmatrix} = \langle 20, -105, -180 \rangle \text{ N-m}$$

b) $\vec{M} = [(\vec{r} \times \vec{F}) \cdot \hat{u}_x]\,\hat{u}_x$ $\quad \hat{u}_x = \langle 1, 0, 0 \rangle$

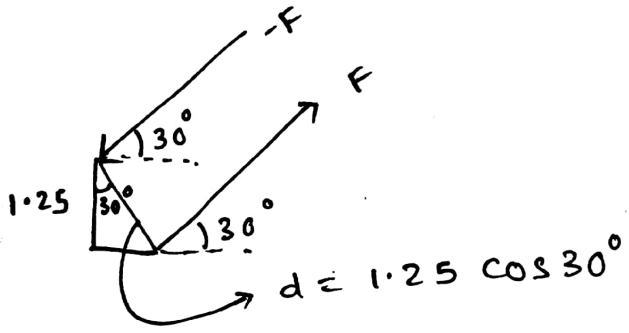
$$= [\langle 20, -105, -180 \rangle \cdot \langle 1, 0, 0 \rangle]\langle 1, 0, 0 \rangle$$

$$\vec{M} = 20\,\hat{i} \text{ N-m}$$

Figure 3



5) Using Figure 3, determine the magnitude of F so that the resultant couple moment is 600 lb.ft counterclockwise. Where on the beam does the resultant couple moment act?



vector way: $[200,0,0]$ $[F\cos 30°, F\sin 30°, 0]$

$\sum \vec{M} = [0,0,-600] = (\vec{r}_1 \times \vec{F}_1) + (\vec{r}_2 \times \vec{F}_2)$

$\vec{r}_1$ = any position vector from line of action of F_1 that is the 200lb force

$\vec{r}_2$ = " " for F_2 that is the unknown $\vec{F}$

$[0,0,-600] = [0,1.5,0] \times [200,0,0] + [0,1.25,0] \times [F\cos 30°, F\sin 30°, 0]$

$F = 277.1281$ N

$\rightarrow \quad \sum M = 600 = 200(1.5) + F(1.25\cos 30°)$

$\Rightarrow \quad F = 277.128$ lb

→ Resultant couple moment can act anywhere on the beam.

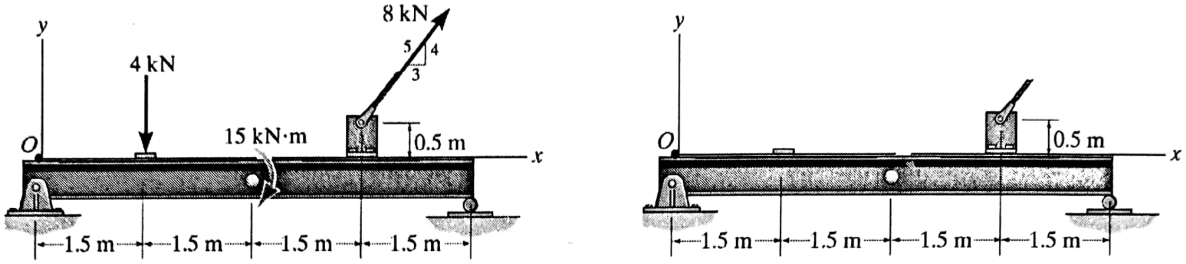


Figure 4

6) Replace the force system acting on the beam in Figure 4 by: (a) an equivalent force and couple moment at point O, and (b) an equivalent force distance x to the right of O. Sketch your equivalent system on the right side of Figure 4.

a) $\Sigma F_x = 8\times\left(\frac{3}{5}\right) = 4.8\ KN$

$\Sigma F_y = 8\times(4/5) - 4 = 2.4\ KN$

$\Sigma M_O = -15 - 4(1.5) - (4.8\times 0.5) + (2.4\times 4.5) = 5.4\ KN\text{-}m$

$\Rightarrow F_R = \langle 4.8, 2.4, 0\rangle\ KN \Rightarrow \boxed{|F_R| = 5.37\ KN}$

$\boxed{M_R = 5.4\ KN\text{-}m}$

b) $\vec{M_R} = \vec{r}\times\vec{F} = (x, 0, 0)\times(4.8, 2.4, 0)$

$\Rightarrow 5.4 = 2.4x$

$\Rightarrow \boxed{x = 2.25\ m}$