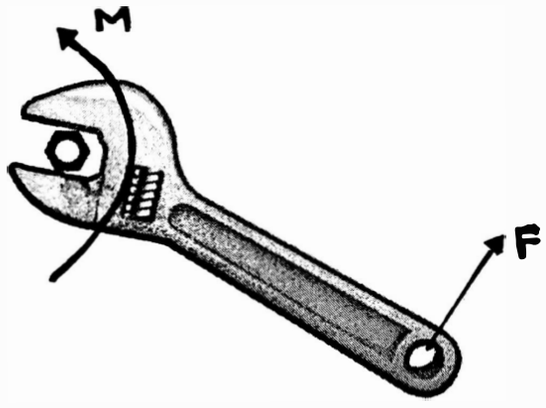
Name: _____
Group members: _____ _____ _____

TAM 210/211 - Worksheet 5

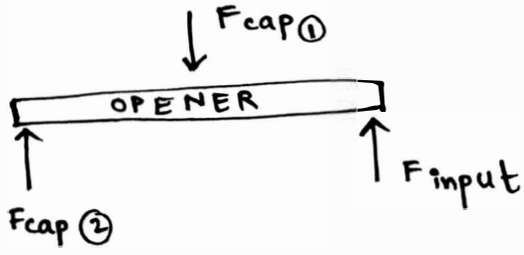
Objectives:

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

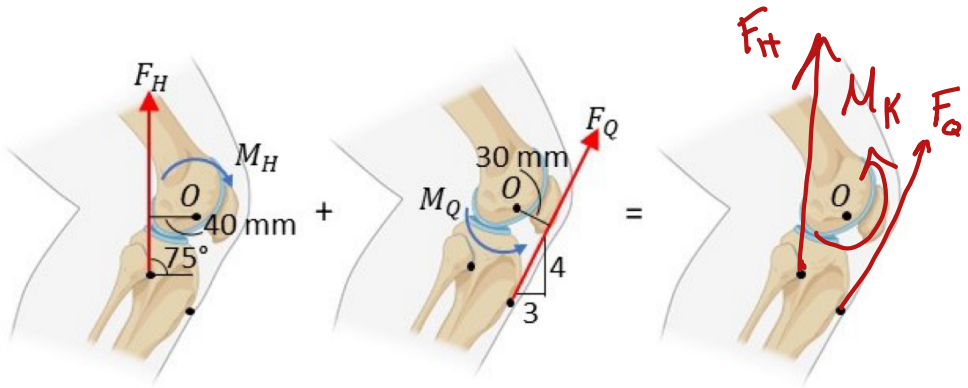
1) Draw the forces and resulting moment that acts on a wrench when unfastening a nut.



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



3) A rotational moment in the knee is generated by the force from the hamstrings (F_H) and the force from the quadriceps (F_Q). The diagram for each muscle is given separately. On the blank knee diagram, draw the forces and resulting moment that acts on the knee when it is in a flexed position.



i) Determine the moment of the force about point O using the scalar formulation.

$M_H = 845(40) = 33{,}800$ N-mm

$M_Q = 1500(30) = 45{,}000$ N-mm

$\Sigma M_K = M_Q - M_H = 11200$ N-mm

$= \boxed{11.2 \text{ N-m}}$

ii) The force generated by the hamstrings and the quadriceps are 845 N and 1500 N, respectively. Determine (a) the $< i, j, k >$ components of F_H and F_Q, (b) the moment of the force about point O using the vector formulation, and (c) the moment of the same force about the x-axis. Is the knee flexing or extending?

a) $F_H = 219\hat{i} + 816\hat{j} + 0\hat{k}$

$F_Q = 900\hat{i} + 1200\hat{j} + 0\hat{k}$

b) $r_H = -38.6\hat{i} + 10.35\hat{j} + 0\hat{k}$

$r_Q = 18\hat{i} + 24\hat{j} + 0\hat{k}$

$$M_H = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -38.6 & 10.35 & 0 \\ 219 & 816 & 0 \end{vmatrix}$$

$= (0-0)\hat{i} - (0-0)\hat{j} + (-38.6(816) - 10.35(219))\hat{k}$

$= \langle 0, 0, -33764 \rangle$ N-mm $= \langle 0, 0, -33.8 \rangle$ N-m

$$M_Q = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 24 & -18 & 0 \\ 900 & 1200 & 0 \end{vmatrix}$$

$= (0-0)\hat{i} - (0-0)\hat{j} + (24(1200) + 18(900))\hat{k}$

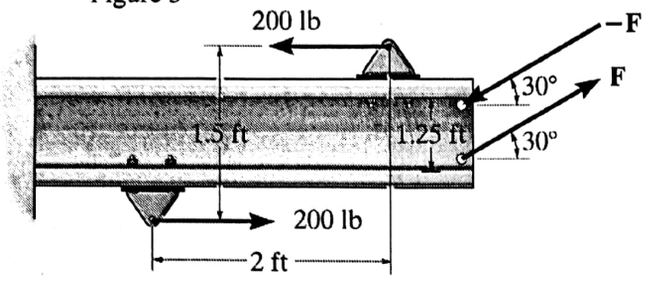
$= \langle 0, 0, 45000 \rangle$ N-mm $= \langle 0, 0, 45.0 \rangle$ N-m

$\Sigma M_k = 45 - 33.8 =$ **11.2 N-m**

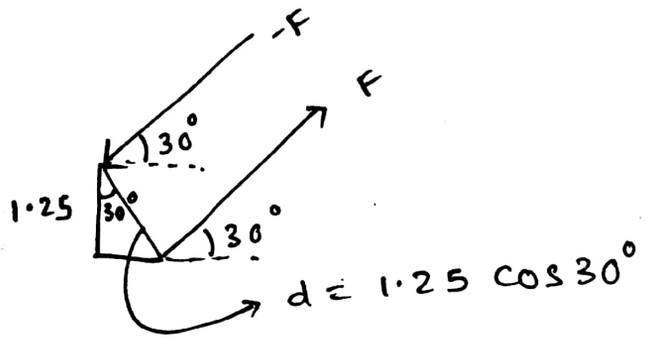
C) $0\hat{i}$

d) Extending

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.

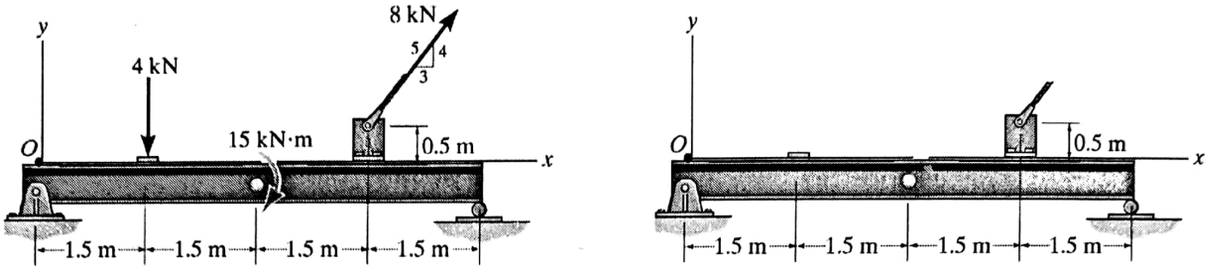


Figure 4

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

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

6.4

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

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

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

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

$\Rightarrow 5.4 = 2.4x$

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