Moment of Force

The moment of a force: <u>is the ability of the force to produce turning or twisting about an axis or point or line</u>.

Mathematically:

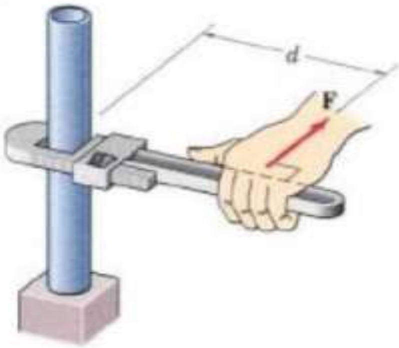
The moment of a force = the applied force X perpendicular distance

$M = F * d$

M = the moment of a force (N.m)

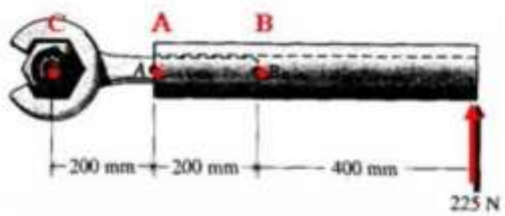
F = applied force (N)

d = perpendicular distance between the point of action of the force and moment center.



Ex (1):

Determine the moment of the force **225 N** about the Points **A** , **B** , and **C** .



Solution:

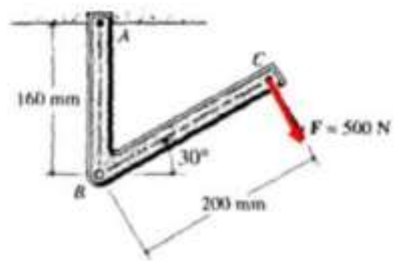
$MA = |F| dA = 225*0.6 = 135\ Nm$

$MB = |F|\ dB = 225*0.4 = 90\ Nm$

$MC = |F|\ dC = 225*0.8 = 180\ Nm$

Ex (2):

Determine the moment of the force **500 N** about the point **A** and **B** .



Solution:

$Cos\ (60) = 200/L$

$Cos\ (60) = dac/(L-160)$

$L = 200/\ Cos\ (60)$

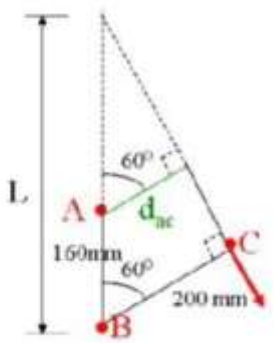
$L = 160 + dac/Cos\ (60)$

$dac = 200 - 160\ Cos\ (60) = 120\ mm$

$dac = 120\ mm$

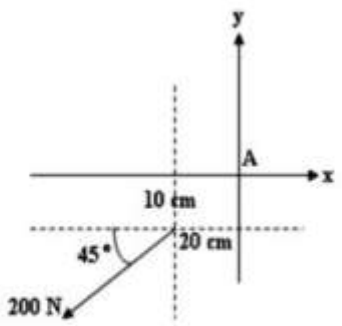
$MA = |F| dAC = 500*0.12 = 60\ Nm$

$MB = |F|\ dB = 500*0.2 = 100\ Nm$



Ex (3) :

Find the moment of the force **200 N** About the point (**A**) shown in fig.



Solution

Fx = F . cos θ = 200 cos 45
= 200 * 0.707 = 141.42 N

Fy = F . sin θ = 200 sin 45
= 200 * 0.707 = 141.42 N

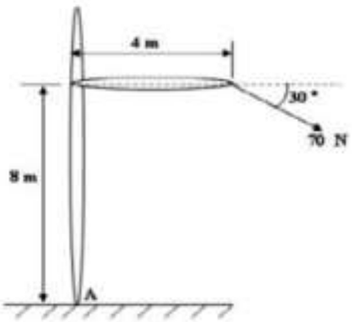
M1 = Fx * d = 141.42 * 10 = 1414.2 N . cm

M2 = Fy * d = 141.42 * 20 = 2828.4 N .cm

M (A) = M1- M2 = - 1414.2 N .cm

Ex (4) :

Determine the moment of the force (**70** N) shown in fig. about the Point (**A**).



Solution

Fx = F . cos θ = 70 cos 30
= 70 * 0.866 = 60.62 N

Fy = F . sin θ = 70 sin 30
= 70 * 0.5 = 35 N

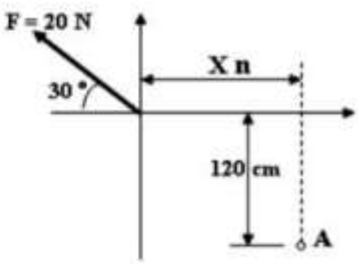
M1 = Fx * d = 60.62 * 8 = 484.97 N . m

M2 = Fy * d = 35 * 4 = 140 N . m

M (A) = M1 + M2 = 484.97 N + 140 = 624.97 N . m

Ex (5) :

Find the distance (**Xn**) , if the moment of the force (**F**) about the point (**A**) is equal to **zero** .



Solution

Fx = F . cos θ = 20 cos 30
= 20 * 0.866 = 17.32 N

Fy = F . sin θ = 20 sin 30
= 20 * 0.5 = 10 N

M1 = Fx * d = 17.32 * 120 = - 2078.46 N . cm

M2 = Fy * d = 10 * Xn = 10 Xn N .cm

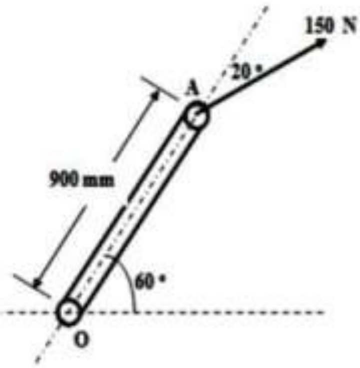
M (A) = - M1+ M2

0 = - 2078.46 + 10 Xn

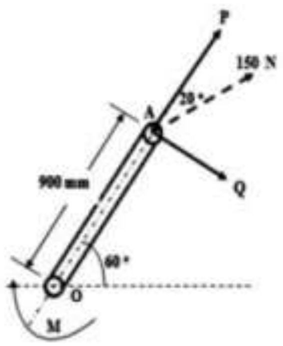
Xn = 2078.46 / 10 = 207.84 cm

Ex.

A (**150 N**) force acts on the end of the (**900 mm**) lever as shown in fig. Determine the moment of the force about (**O**) .



Solution

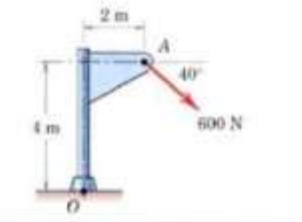


Q = 150 sin 20 = 51.3 N

Mo = - Q (0.9) = - 51.3 * 0.9 = - 46.2 N.m = 64.2 N.m

Ex(8):

Calculate the magnitude of the moment about the base point O of the 600-N force in five different ways.

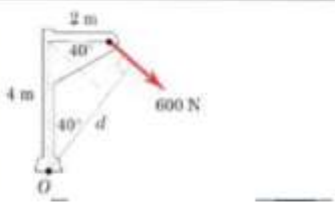


Solution. (*I*) The moment arm to the 600-N force is

$$d = 4 \cos 40° + 2 \sin 40° = 4.35 \text{ m}$$

① By $M = Fd$ the moment is clockwise and has the magnitude

$$M_O = 600(4.35) = 2610 \text{ N}\cdot\text{m} \qquad \textit{Ans.}$$



(*II*) Replace the force by its rectangular components at A

$$F_1 = 600 \cos 40° = 460 \text{ N}, \quad F_2 = 600 \sin 40° = 386 \text{ N}$$

By Varignon's theorem, the moment becomes

② $$M_O = 460(4) + 386(2) = 2610 \text{ N·m} \qquad \textit{Ans.}$$

(III) By the principle of transmissibility, move the 600-N force along its line of action to point B, which eliminates the moment of the component F_2. The moment arm of F_1 becomes

$$d_1 = 4 + 2 \tan 40° = 5.68 \text{ m}$$

and the moment is

$$M_O = 460(5.68) = 2610 \text{ N·m} \qquad \textit{Ans.}$$

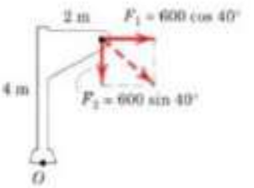
③ ***(IV)*** Moving the force to point C eliminates the moment of the component F_1. The moment arm of F_2 becomes

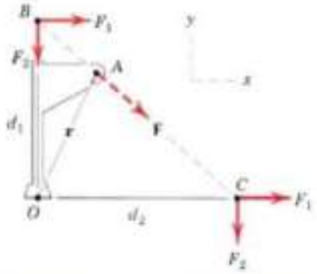
$$d_2 = 2 + 4 \cot 40° = 6.77 \text{ m}$$

and the moment is

$$M_O = 386(6.77) = 2610 \text{ N·m} \qquad \textit{Ans.}$$

(V) By the vector expression for a moment, and by using the coordinate system indicated on the figure together with the procedures for evaluating cross products, we have





④ $$\begin{aligned}\mathbf{M}_O &= \mathbf{r} \times \mathbf{F} = (2\mathbf{i} + 4\mathbf{j}) \times 600(\mathbf{i} \cos 40° - \mathbf{j} \sin 40°) \\ &= -2610\mathbf{k} \text{ N·m}\end{aligned}$$

The minus sign indicates that the vector is in the negative z-direction. The magnitude of the vector expression is

$$M_O = 2610 \text{ N·m} \qquad \textit{Ans.}$$

Helpful Hints

① The required geometry here and in similar problems should not cause difficulty if the sketch is carefully drawn.

② This procedure is frequently the shortest approach.

③ The fact that points B and C are not on the body proper should not cause concern, as the mathematical calculation of the moment of a force does not require that the force be on the body.

④ Alternative choices for the position vector $\mathbf{r}$ are $\mathbf{r} = d_1\mathbf{j} = 5.68\mathbf{j}$ m and $\mathbf{r} = d_2\mathbf{i} = 6.77\mathbf{i}$ m.