Forces and Moments: Part 1

Moment of Force \( \mathbf{F} \) around point \( O \): \( \mathbf{M}_O \)

The moment of a force about a point or an axis provides a measure of the tendency of the force to cause a body to rotate about the point or axis.

<table>
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<tr>
<th>oz \perp \text{plane xoy in which } F_x \text{ lies}</th>
<th>\begin{align*} F_x &amp; \text{ causes the pipe to turn about the z-axis} \ F_x &amp; \text{ causes a moment about the z-axis } = (\mathbf{M}_O)_z \end{align*}</th>
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| \begin{align*} F_y \text{ passes through } O \\ F_y & \text{ does not cause the pipe to turn because the line of action of the force passes through } O. \end{align*} | \begin{align*} \begin{array}{c} \text{\begin{tabular}{c} \( \mathbf{F}_y \) passes through } O \text{.} \\ \end{tabular} \\ \text{\begin{tabular}{c} \( F_y \) \text{ does not cause the pipe to turn because}
\text{\begin{tabular}{c} \( \text{the line of action of the force passes through } O. \end{tabular}} \end{tabular}} \end{align*} |
| ox \perp \text{plane zoy in which } F_z \text{ lies} | \begin{align*} F_z & \text{ causes the pipe to turn about the x-axis} \\ F_z & \text{ causes a moment about the x-axis } (\mathbf{M}_O)_x \end{align*} |


Direction of the moment:

The direction of $M_o$ would be specified by using the right hand rule.

Counter Clockwise (CCW) is out of the page, Clockwise (CW) is into the page.

Magnitude of the moment:

$|M_o| = Fd$
Calculating the moment in 2-D using components:

1) Select a positive direction (CCW or CW),
2) Calculate each moment and add them, using the proper sign for each term,
3) Always remember to write the unit of moment which is Nm.

Example:

In the following figure, calculate the moment about the point O:

1) We choose the CCW as positive direction for moment,
2) Moment of component of $F$ along $x$ about O is $Fx$ times the perpendicular distance from O (or $d_1$), which is clockwise, so it is $-F_xd_1$
3) Moment of component of $F$ along $y$ about O is $Fy$ times the perpendicular distance from O (or $d_2$), which is counter clockwise, so it is $F_yd_2$
4) Moments add together as vectors, so the total moment is:

$$M_o = -F_xd_1 + F_yd_2$$
Example:

In the following figure, if $\theta$ is 60 degrees and $r$ is 30 mm and $F$ is 6 N, what is the magnitude of the moment about O.

1) We choose the CCW as positive direction for moment,
2) Component of $F$ along $r$ (or $F||$) produces no moment, since it passes from point O.
3) Component of $F$ perpendicular to $r$ (or $F_\perp = F \sin \theta$)

produces the moment $Fr \sin \theta$.

So the total moment of $F$ about O is:

$$M_O = F_\perp r = (F \sin \theta) r = 6 \times \sin 60 \times 0.03 = 0.156 \text{ Nm}.$$