Moments - 1

ME 202

Definitions

• A moment is a vector that expresses the tendency of a force to rotate a body around a specified point (the moment center).

• The moment arm of a force is the perpendicular distance from the moment center to the line of action of the force.

What determines the magnitude of a moment?

The magnitude of a force's moment equals the magnitude of the force times its moment arm.

\[ |\vec{M}_P| = |\vec{F}| \cdot d \]

For force \( F_1 \):
\[ |\vec{M}_O| = F_1 \cdot x_1 \]

For force \( F_2 \):
\[ |\vec{M}_o| = F_2 \cdot x_2 \]

For force \( F_1 \):
\[ |\vec{M}_P| = F_1 \cdot (x_2 - x_1) \]

For force \( F_2 \):
\[ |\vec{M}_P| = 0 \]

If \( F_1 = F_2 \), then \( F_1 \) has the larger moment about \( O \), because it has the larger moment arm (\( x_2 > x_1 \)).

If \( F_1 \cdot x_1 = F_2 \cdot x_2 \), then the two forces have equal moments about \( O \).
How do we represent the direction of a moment?

- Since we represent moments as vectors, every moment must have both magnitude and direction. What is the direction of a moment?
- We define it as perpendicular to the plane containing the moment center and the line of action of the force. But which way?

Which way?

- Use the right hand rule (RHR).
- Recall that a moment is a vector that expresses the tendency of a force to rotate a body around a specified point.
- Curl the fingers of your right hand in the direction of the rotation that the force tends to cause. Then the thumb of your right hand points in the direction that we define as the moment’s direction.

The Moment Vector

Since we have defined both the magnitude and the direction of a force’s moment, we now have a complete definition for the moment vector.

\[
\vec{M}_P = (\vec{F} \cdot d) \hat{u}
\]

- moment of \( \vec{F} \) about \( P \)
- perpendicular distance from \( P \) to line of action of \( \vec{F} \)
- magnitude of \( \vec{F} \)
- unit vector determined by RHR

The moment about \( P \) is clockwise (CW), so the moment’s direction is into the image (pointing away from you).

The moment about \( P \) is counterclockwise (CCW), so the moment’s direction is out of the image (pointing toward you).
Moments - 1

1. The moment of a force about a point must become something that you understand completely. The following slides give the definition and explain it in detail.

2. Because the moment of a force about a point (called the “moment center”) is the product of a force and a distance, its dimensions are force times distance. Typical units are $N \cdot m$ or $ft \cdot lb$. Moments tend to rotate or twist things and are often referred to as “torque.” But because nothing moves in this class, the moments do not cause rotation - they only try to cause it.

3. The moment arm is the shortest distance between the moment center and the line of action of the force. If we change the position of the moment center, or the position of the force’s line of action or the magnitude of the force, then we change the magnitude of the force’s moment.

4. Because the magnitude of a moment depends on both the size of the applied force and the force’s moment arm, the larger of two forces does not necessarily have the larger of two moments about a given moment center. We use this fact intuitively when we adjust the point at which we apply a force so as to get more “leverage.” (Remember the see-saw/teeter-totter?) When Archimedes stated that with a place to stand and a long
enough lever he could move Earth, he was simply saying “The longer the moment arm, the bigger the mo-
ment.”

5 The moment center and the line of action of a force determine a plane. There are two directions perpendicu-
lar to that plane, one pointing toward one side of the plane and one pointing toward the other. One of the
these, and only one, is the direction that we associate with the moment of the force about the moment center.

6 If reading this slide does not help you to visualize the right hand rule, then perhaps you are more of a visual
learner than a textual learner. Fear not, the next slide has pictures!

7 Go ahead, use your right hand. Read the previous slide again. This is a simple but crucial concept. If you do
not get it, you will regret it. “Maybe not today, maybe not tomorrow - but soon and for the rest of your
life.” (Humphrey Bogart)

8 The equation on this slide expresses the moment about a point $P$ of a force $\vec{F}$. When you see this equation,
all of the boxed notes should come to mind.