# Statics - TAM 210 & TAM 211

**Lecture 7**

**January 31, 2018**

# Announcements

- Upcoming deadlines:
- Quiz 1 (1/31-2/2)
  - Reserve testing time at CBTF
  - https://cbtf.engr.illinois.edu/sched/
  - NO MAKE-UP.
  - Lectures 1- 4 material
- Friday (2/1)
  - Mastering Engineering Tutorial 4
- Tuesday (2/6)
  - PL Homework 3
- Quiz 2 (2/7-9)
  - Reserve testing time at CBTF

# Recap: Equations of equilibrium

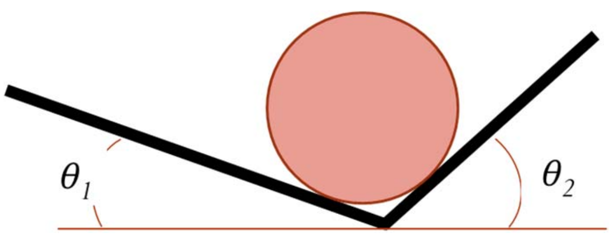
- Use FBD to write equilibrium equations in x, y, z directions
  - $\sum \overrightarrow{F_x} = 0, \sum \overrightarrow{F_y} = 0,$ and if 3D $\sum \overrightarrow{F_z} = 0,$
  - If # equations ≥ # unknown forces, **statically determinate** (can solve for unknowns)
  - If # equations < # unknown forces, **indeterminate** (can **NOT** solve for unknowns), need more equations
- Get more equations from FBD of other bodies in the problem

# Recap: Idealizations

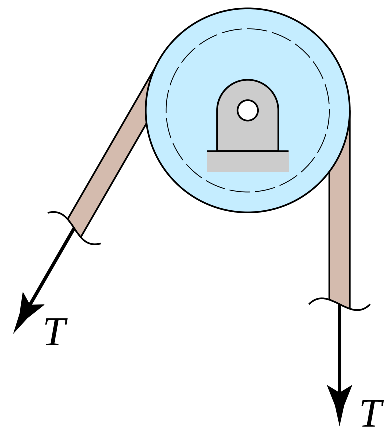
**Smooth surfaces:** regarded as frictionless; force is perpendicular to surface

**Pulleys:** (usually) regarded as frictionless; tension around pulley is same on either side.

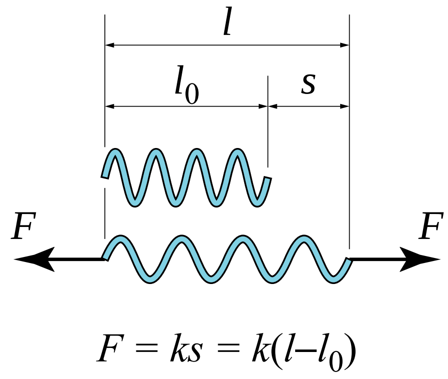
**Springs**: (usually) regarded as linearly elastic; tension is proportional to *change* in length *s*.



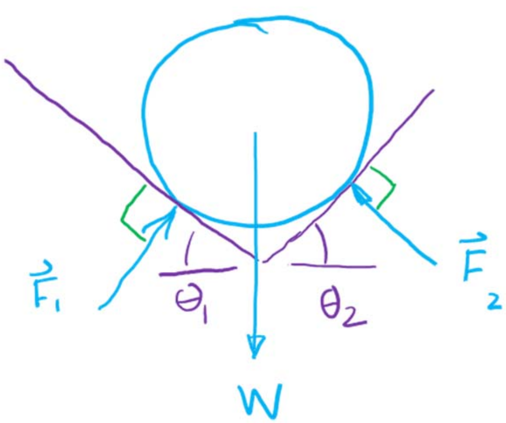

Smooth surface

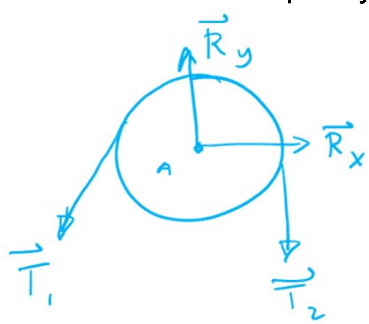



Frictionless pulley




Linearly elastic spring




$|\vec{T}_1| = |\vec{T}_2|$

Assuming cable is massless & rigid

Magnitudes are same

Directions do not need to be the same

$s = l_f - l_0$

if $s > 0 \rightarrow$ elongation

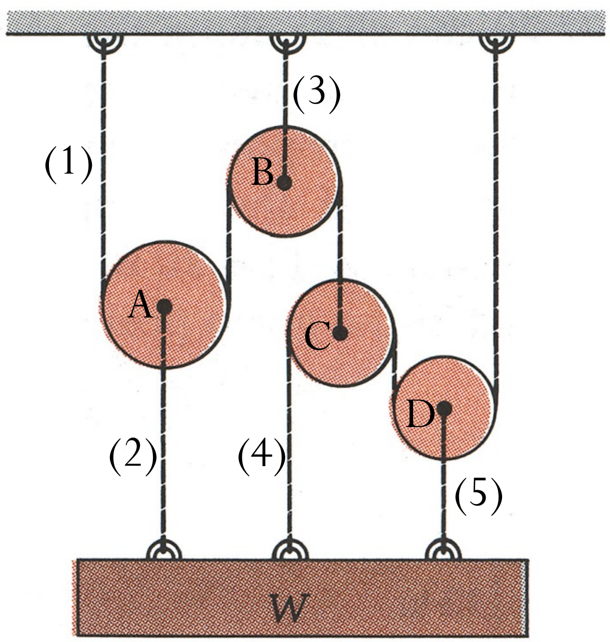
if $s < 0 \rightarrow$ compression

# Equilibrium of a system of particles

Some practical engineering problems involve the statics of interacting or interconnected particles. To solve them, we use Newton's first law

$$\Sigma \mathbf{F} = \mathbf{0}$$

on selected multiple free-body diagrams of particles or groups of particles.




The five ropes can each take 1500 N without breaking. How heavy can $W$ be without breaking any?

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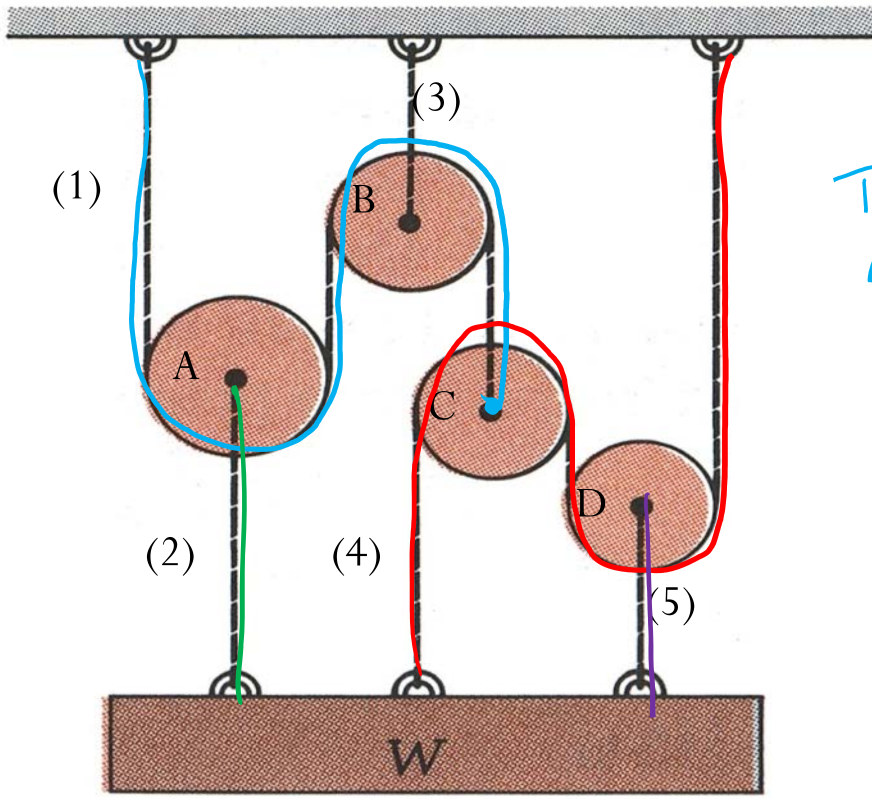
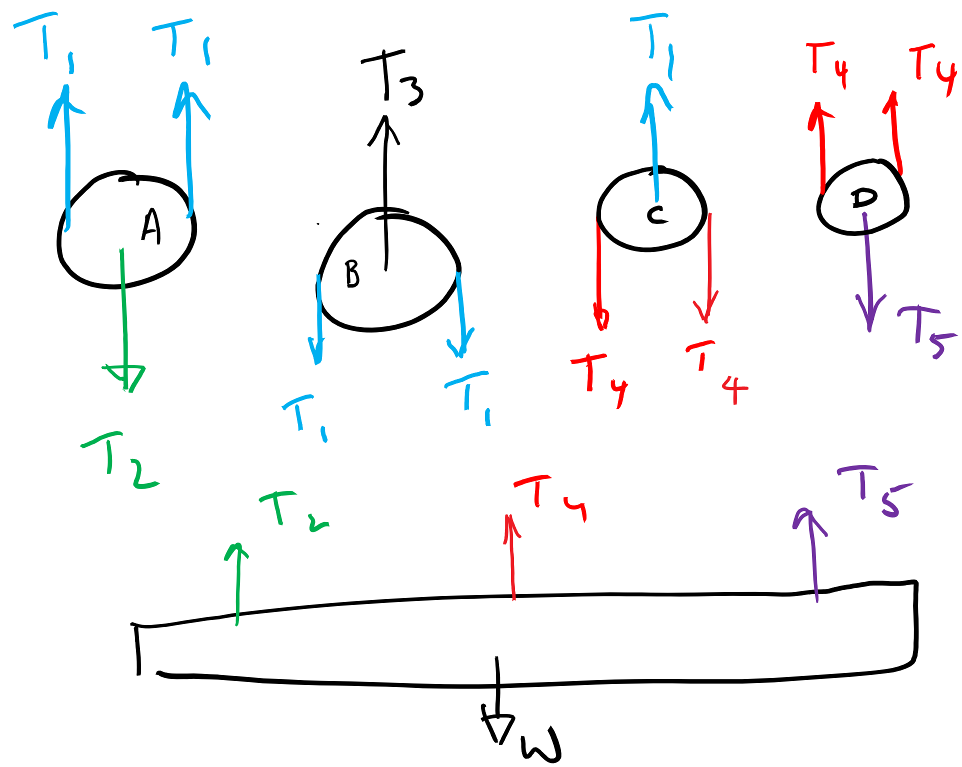



Note: No pin jt reaction forces at center of pulleys because these pulleys are not secured to a fixed (or grounded) pin jt.



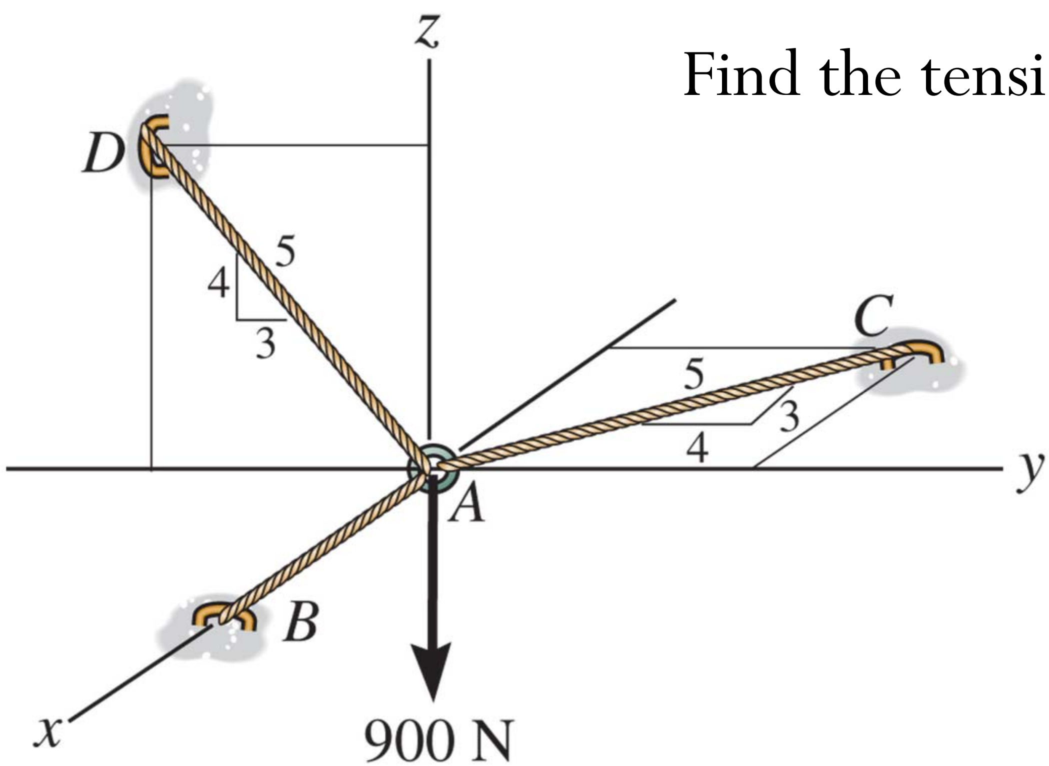

$\Sigma F_y = 0$

write eqns of equilibrium from each FBD

# 3D force systems

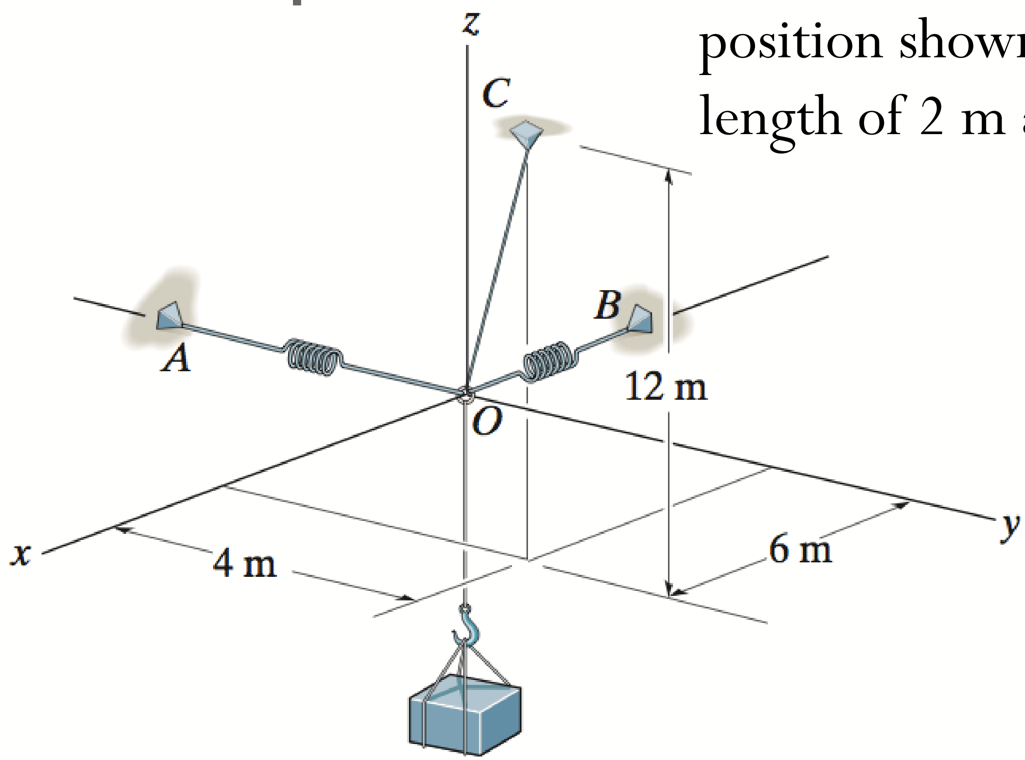
Use $\Sigma \overrightarrow{F_x} = 0, \Sigma \overrightarrow{F_y} = 0, \Sigma \overrightarrow{F_z} = 0$

Find the tension developed in each cable



# Example – 3D

Determine the stretch in each of the two springs required to hold the 20-kg crate in the equilibrium position shown. Each spring has an unstretched length of 2 m and a stiffness of $k = 360$ N-m.



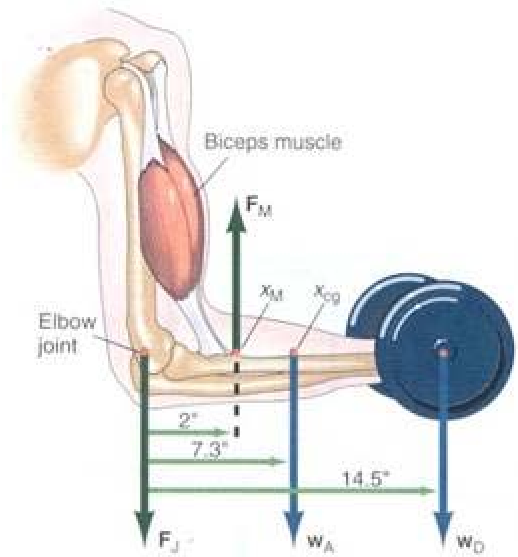
# Chapter 4: Force System Resultants

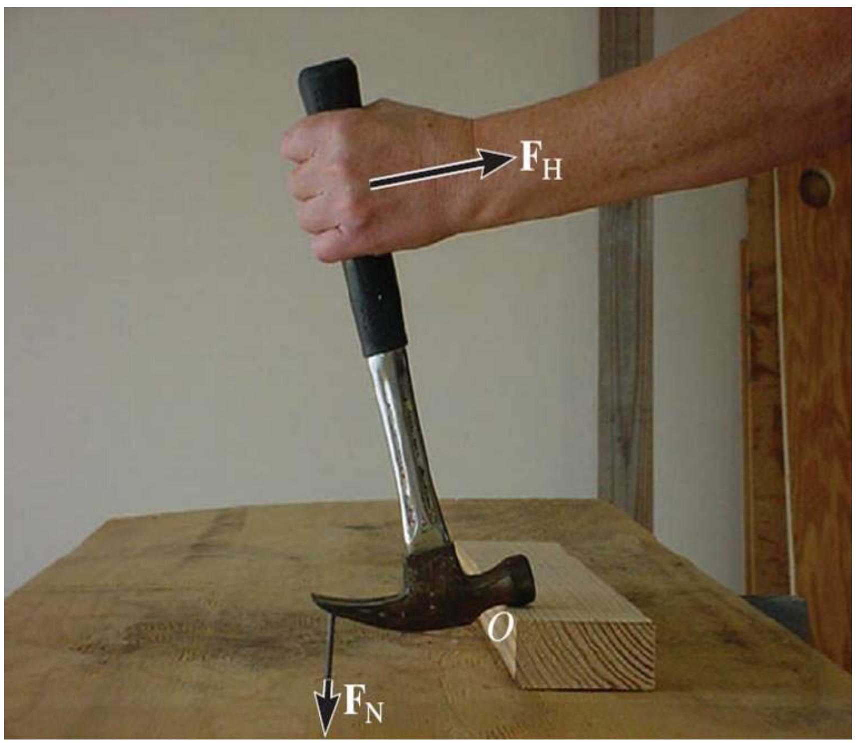
# Goals and Objectives

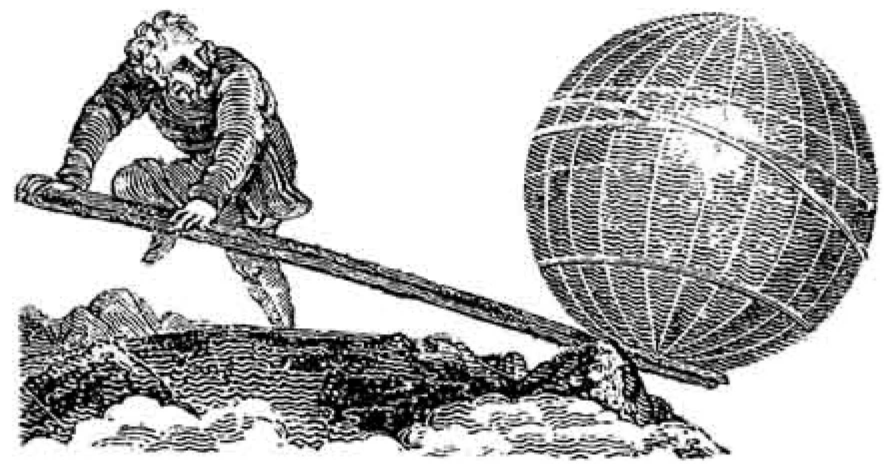
- Discuss the concept of the moment of a force and show how to calculate it in two and three dimensions
- How to find the moment about a specified axis
- Define the moment of a couple
- Finding equivalence force and moment systems
- Reduction of distributed loading

# Moment of a force

The **moment of a force about a point** provides a measure of the **tendency for rotation** (sometimes called a torque).



**Moment** 1.A very brief period of time. An exact point in time. 2. Importance. **3. A turning effect produced by a force acting at a distance on an object.** Oxford Dictionary

# Moment of a force – scalar formulation

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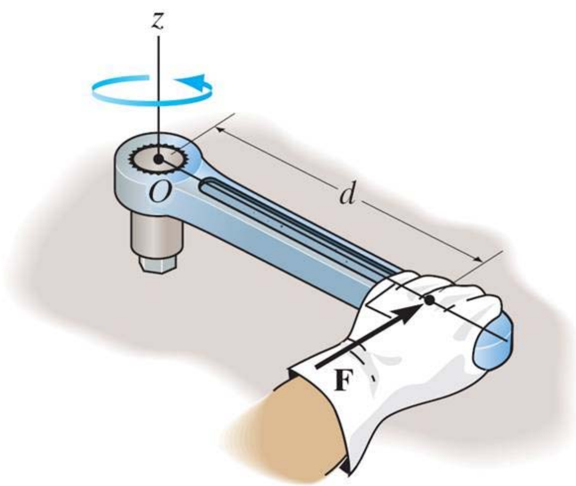
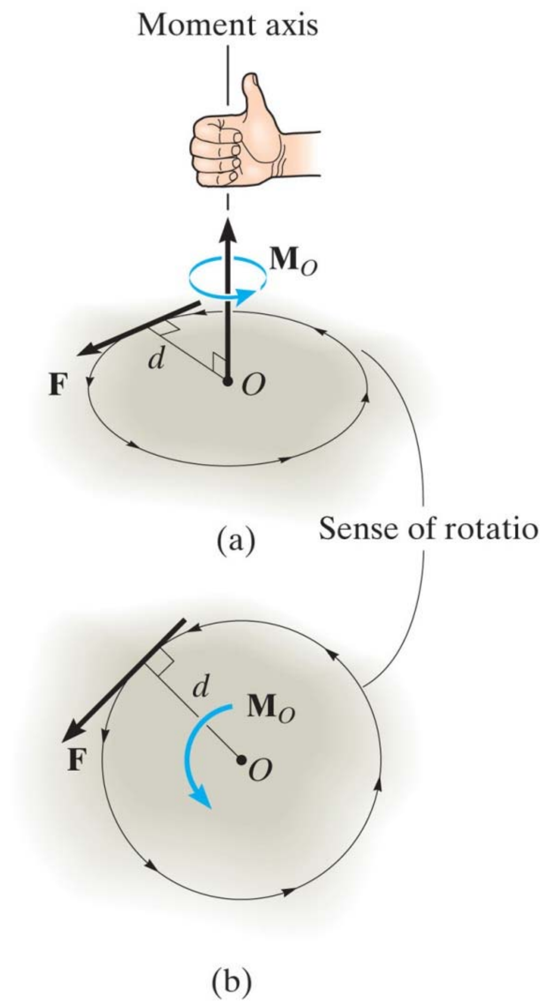
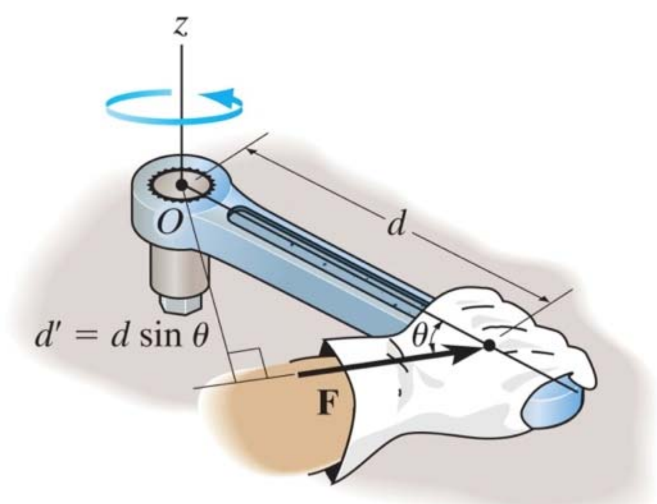


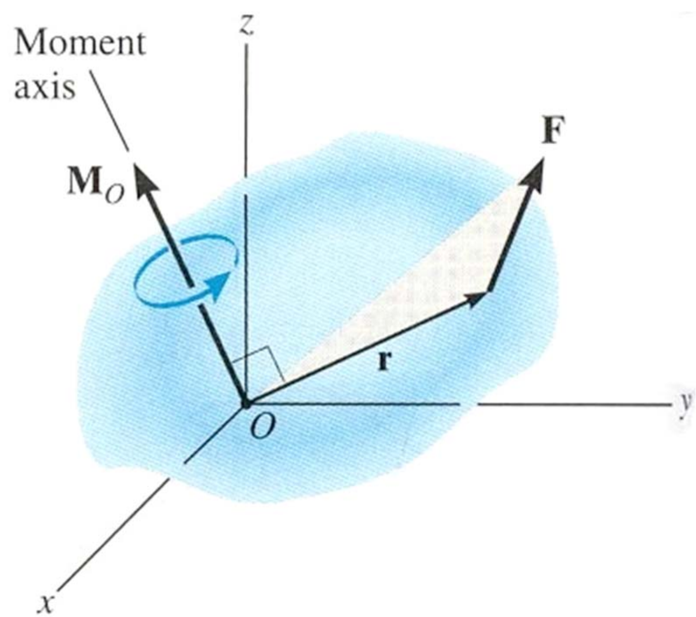



# Moment of a force – vector formulation

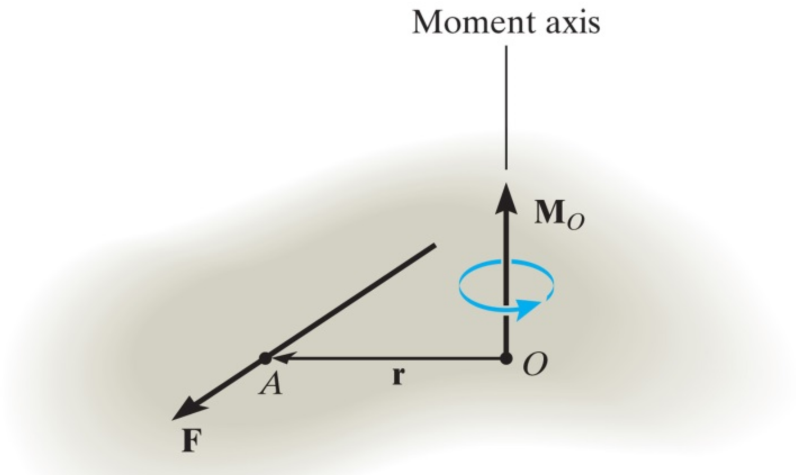
The moment of a force $\vec{F}$ about point O, or actually about the moment axis passing through O and perpendicular to the plane containing O and $\vec{F}$, can be expressed using the cross (vector) product, namely:

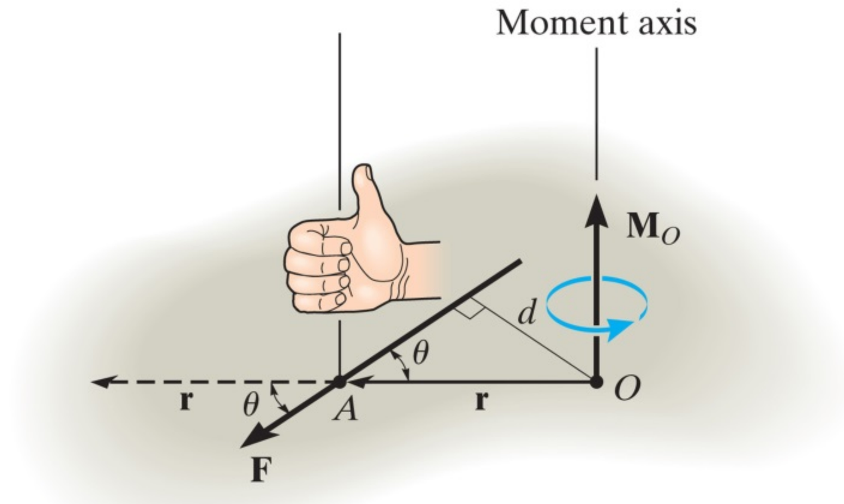
where $\vec{r}$ is the position vector directed from O to any point on the line of action of $\vec{F}$.



# Moment of a force – vector formulation



# Example

**Given:** The angle $\theta = 30°$ and $x = 10$ m.

**Find:** The moment by $\vec{P}$ about point O.