ENSC 2113
Engineering Mechanics: Statics

Chapter 4:

Force System Resultants

(Section 4.6-4.8)

COLLEGE OF
ENGINEERING, ARCHITECTURE
AND TECHNOLOGY

Chapter 4 Outline:

4.1 Moment of a Force – Scalar Formulation

4.2 Cross Product

4.3 Moment of a Force – Vector Formulation

4.4 Principle of Moments

4.5 Moment of a Force about a Specified Axis

4.6 Moment of a Couple

4.7 Simplification of a Force and Couple System

4.8 Further Simplification of a Force and Couple System

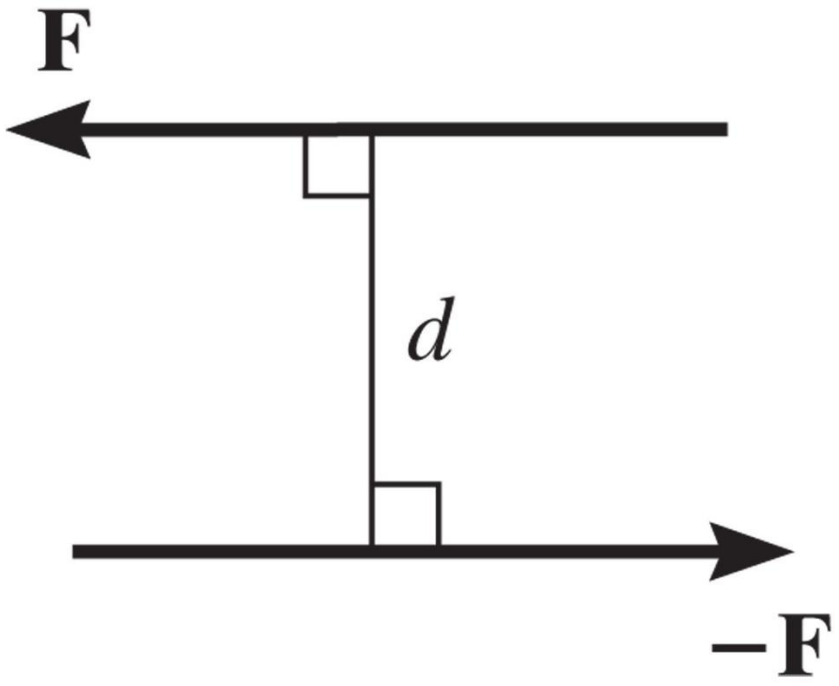
4.9 Reduction of a Simple Distributed Loading

Chapter 4 Objectives:

- To discuss the concept of the moment of a force and show how to calculate it in two and three dimensions
- To provide a method for finding the moment of a force about a specified axis
- To define the moment of a couple
- To show how to find the resultant effect of a nonconcurrent force system
- To indicate how to reduce a simple distributed loading to a resultant force acting at a specified location

4.6 Moment of a Couple:

- A **couple** is defined as two parallel forces of the same magnitude, but opposite directions

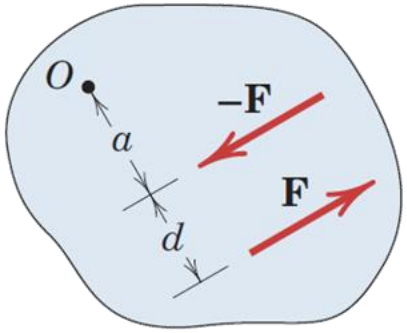


4.6 Moment of a Couple:

- The summation of forces is equal to zero.

$$\sum F = 0 = -F + F$$

- The moment produced by a couple is called a **couple moment**
- This moment may be determined by summation of moments about **any** point

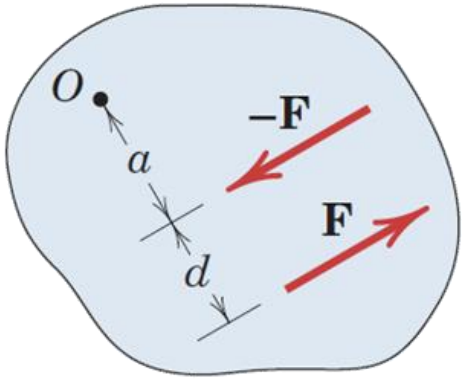


4.6 Moment of a Couple:

- Magnitude is independent of point of rotation
  - Summation at point O

$$+ccw\sum M_o = -F(a)+F(a+d)$$

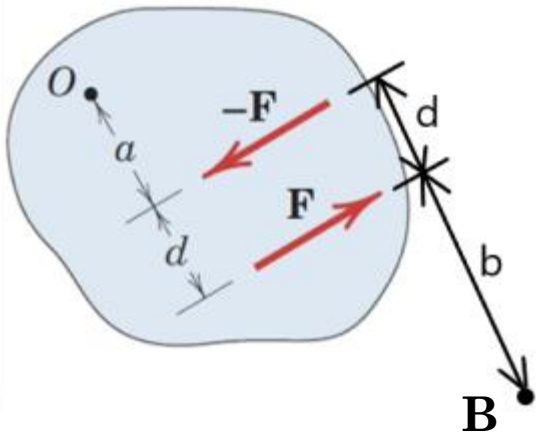
$$+ccw\sum M = F(d)$$



  - Summation at point B

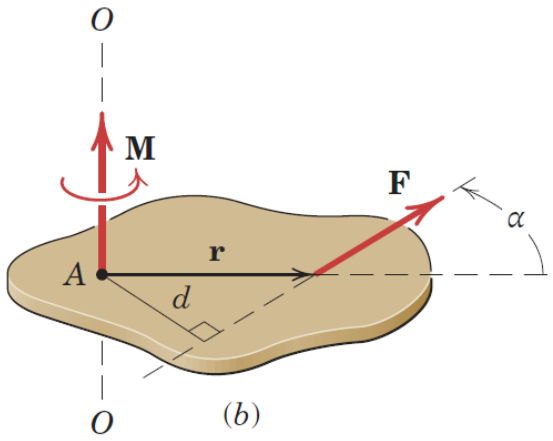
$$+ccw\sum M_B = -F(b)+F(b+d)$$

$$+ccw\sum M = F(d)$$



4.6 Moment of a Couple:

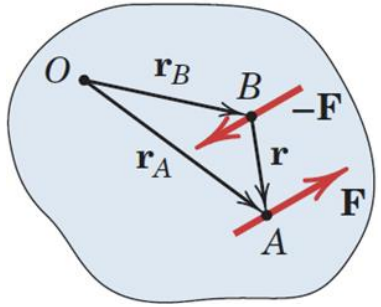
- Recall,
  - Position Vector = $\vec{r}$
  - Moment Vector = $\overrightarrow{M} = \vec{r} \times \overrightarrow{F}$



- For the couple forces:
- $\overrightarrow{M_o} = \left\{\overrightarrow{r_A} \times \overrightarrow{F}\right\} + \left\{\overrightarrow{r_B} \times -\overrightarrow{F}\right\}$

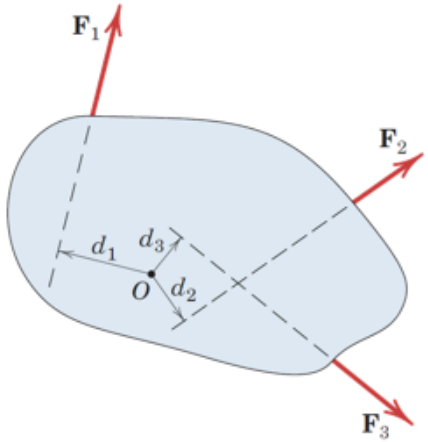
  $= \overrightarrow{M_o} = \left(\overrightarrow{r_A} - \overrightarrow{r_B}\right) \times \overrightarrow{F}$

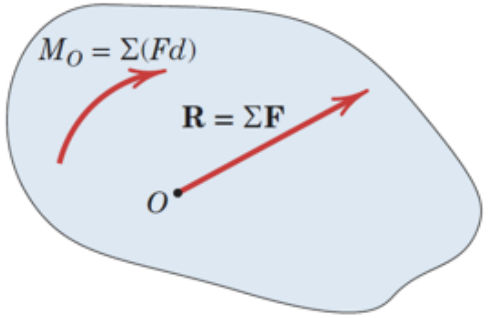
  $= \overrightarrow{M_o} = \vec{r} \times \overrightarrow{F}$

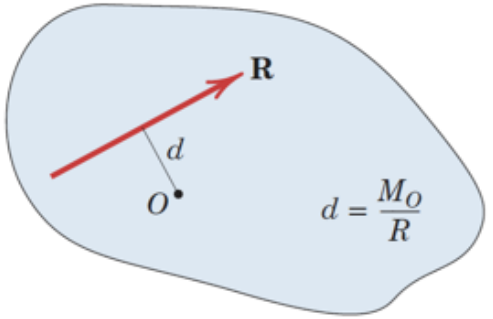


4.7-4.8 Simplification of a Force and Couple System:

- Reduce the system of forces and couple moments acting on a body to a simpler form by replacing with an **equivalent system**
- A system is equivalent if the **external effects** on a rigid body are the same as the original system







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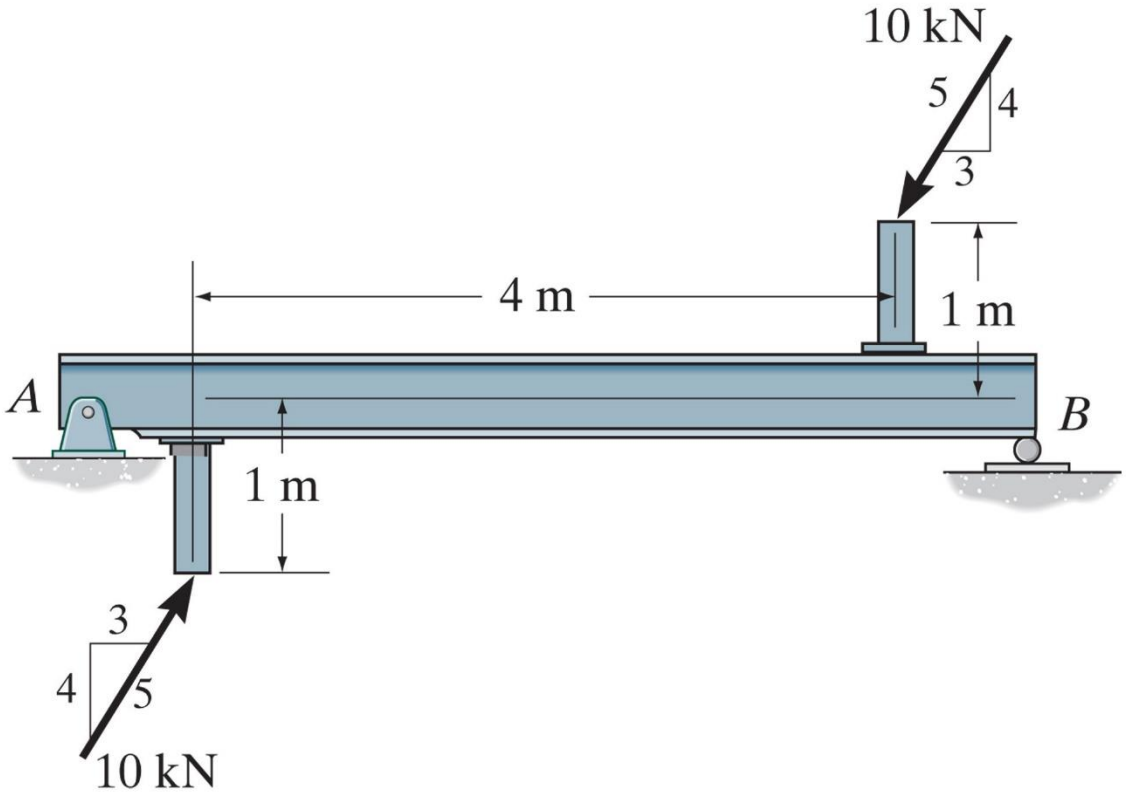
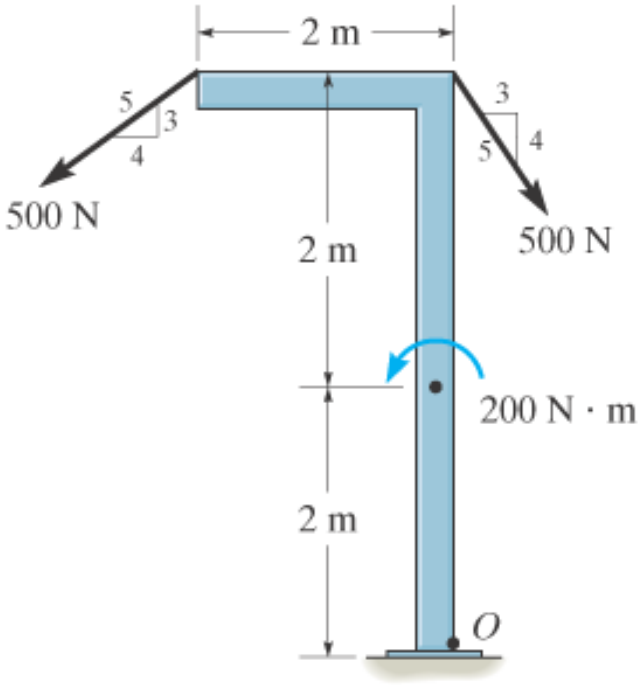
Example:

- Determine the resultant couple moment acting on the beam.



Example:

- Determine x and y components of the resultant force and the resultant couple moment at point O.



Example:

- Equivalent Force Systems: