Today:

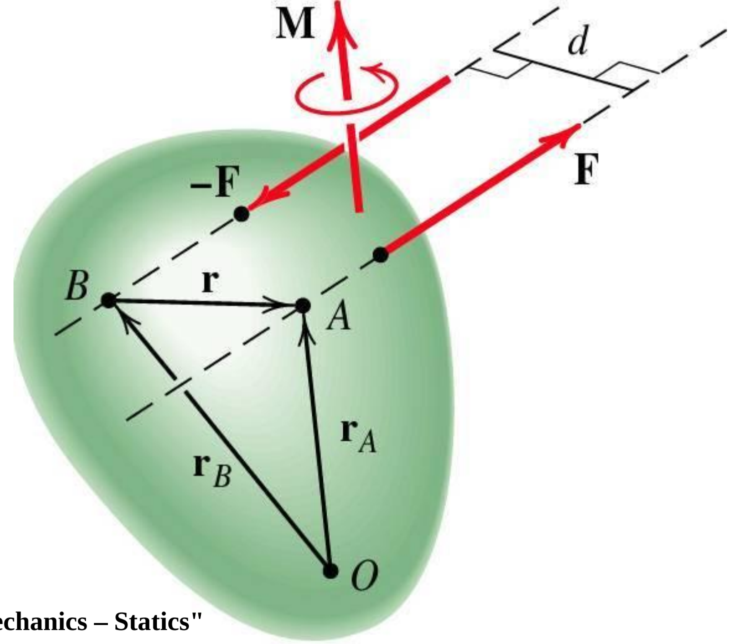
3D continued

Book: Chapter 5.5-5.6

Couple in 3D

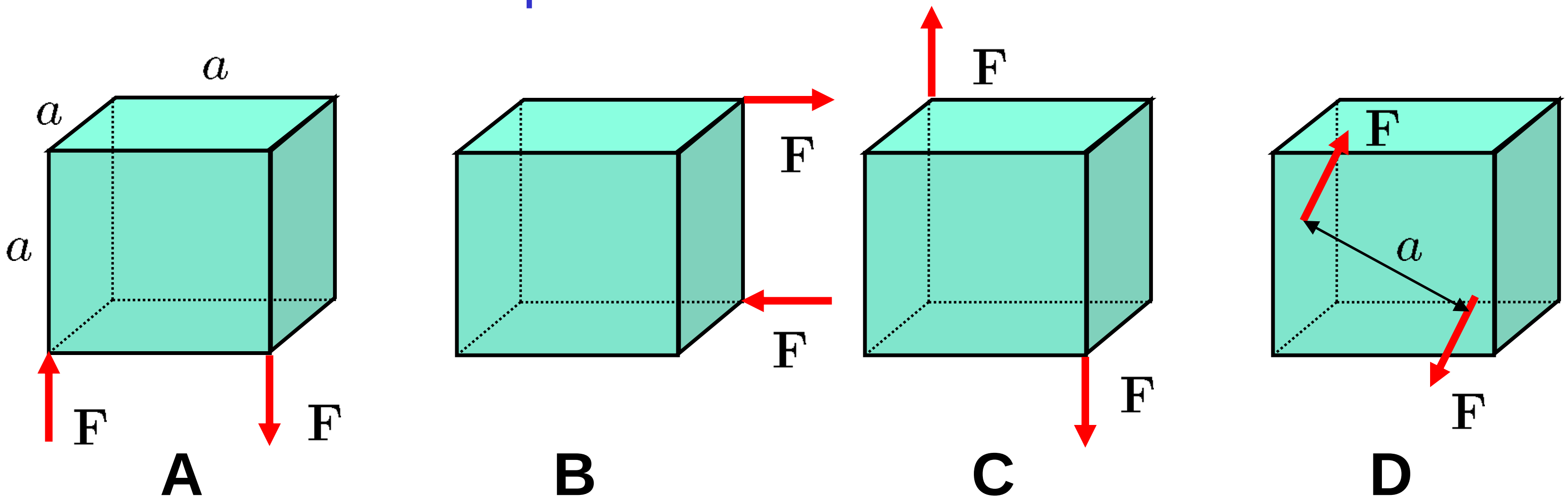
$$\mathbf{M} = \mathbf{r}_A \times \mathbf{F} + \mathbf{r}_B \times (-\mathbf{F}) =$$

$$(\mathbf{r}_A - \mathbf{r}_B) \times \mathbf{F} = \mathbf{r} \times \mathbf{F}$$

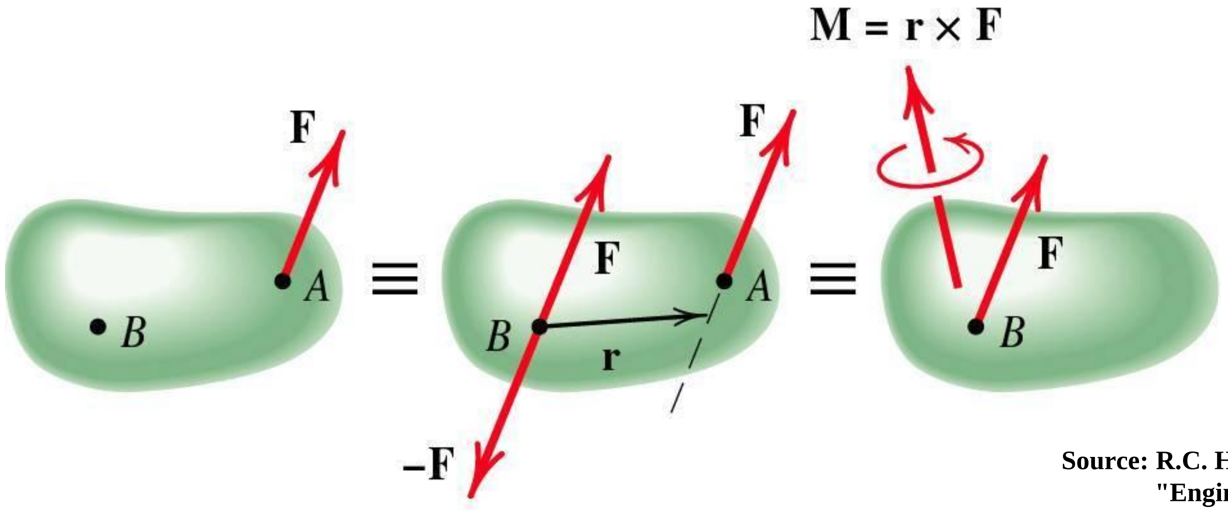


Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

Which of these couples is different?



Force-Couple systems



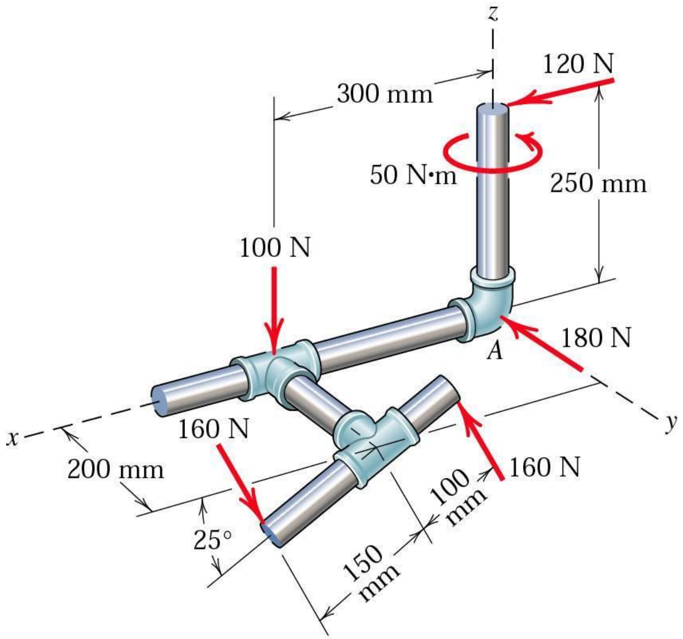
Source: R.C. Hibbeler,
"Engineering Mechanics – Statics"

Equivalent Force-Couple system

A single resultant force and a moment that replaces all forces and couples in a body

$$\mathbf{R} = \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3 + \ldots = \sum \mathbf{F}$$

$$\mathbf{M} = \mathbf{M}_1 + \mathbf{M}_2 + \mathbf{M}_3 + \ldots = \sum (\mathbf{r} \times \mathbf{F})$$



Represent the resultant of the force system acting on the pipe assembly by a single force **R** at *A* and a couple **M**.

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

Static equilibrium of a body (Newton's first law)

The equivalent force and moment in any point is equal to zero.

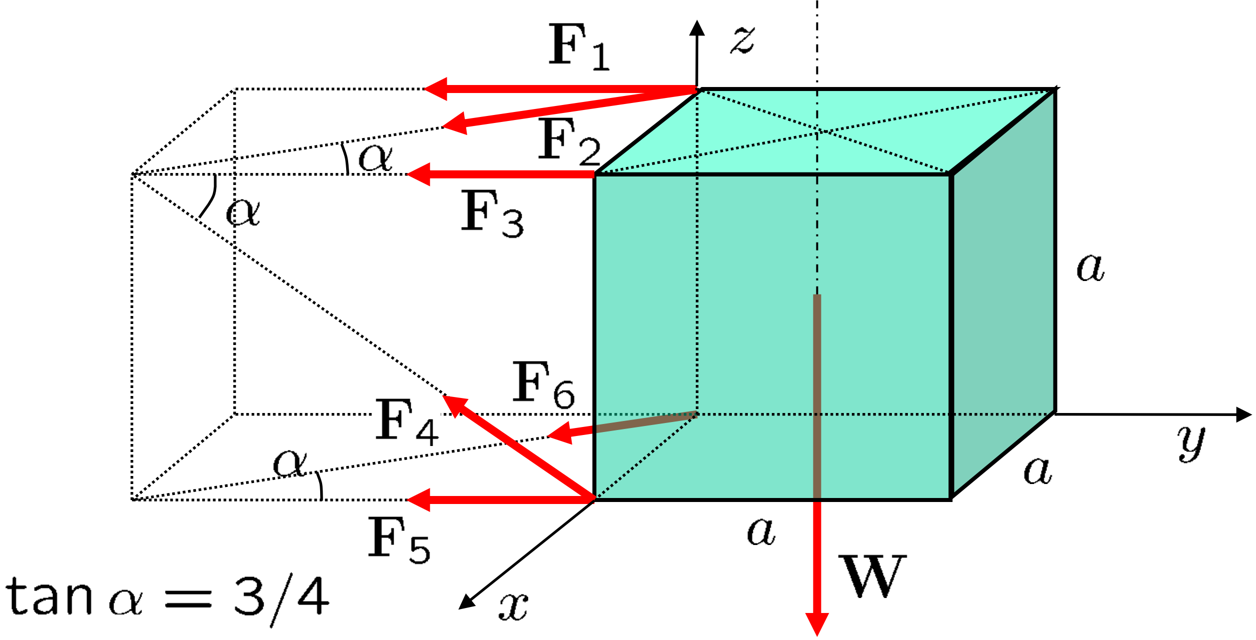
$$\mathbf{R} = \sum \mathbf{F} = \mathbf{0}$$

$$\mathbf{M} = \sum (\mathbf{r} \times \mathbf{F}) = \mathbf{0}$$

Static equilibrium

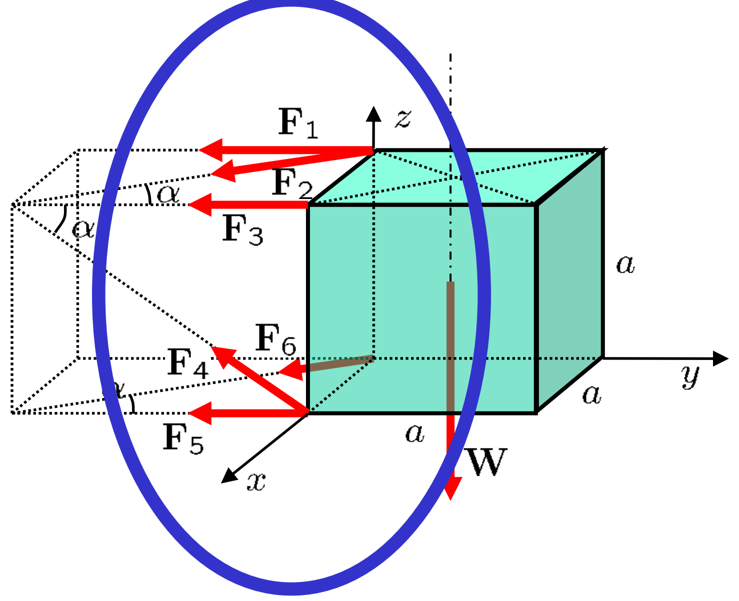
$$\sum \mathbf{F} = \mathbf{0} \quad \text{or} \quad \begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \\ \sum F_z = 0 \end{cases}$$

$$\sum \mathbf{M} = \mathbf{0} \quad \text{or} \quad \begin{cases} \sum M_x = 0 \\ \sum M_y = 0 \\ \sum M_z = 0 \end{cases}$$

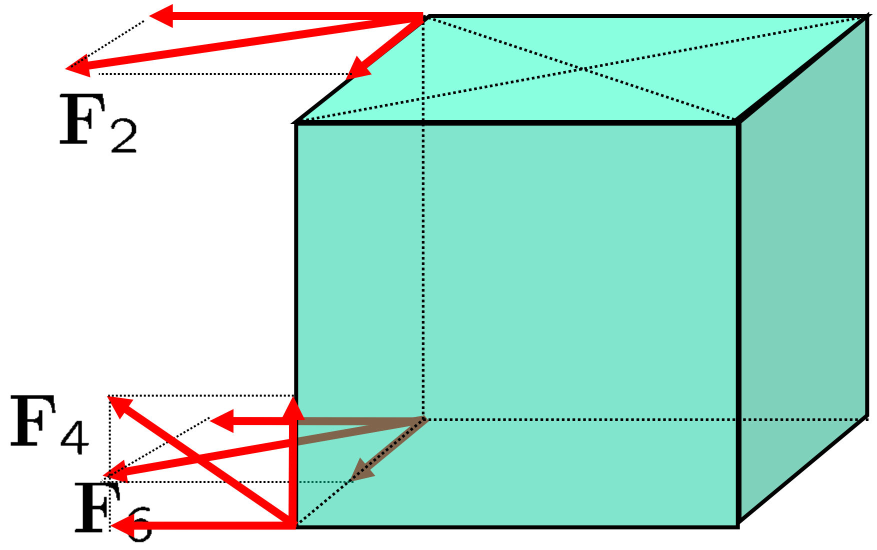


The cube with weight W=24 N and dimensions *a*=1 m is in equilibrium.

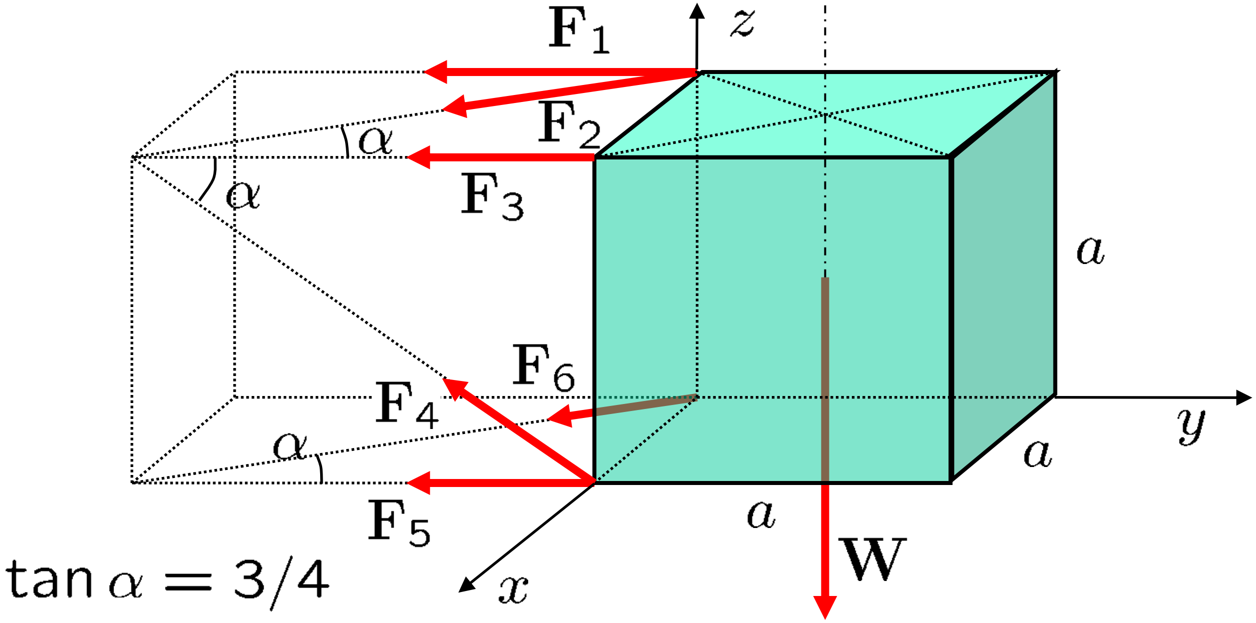
Calculate F_1 to F_6.



$\mathbf{F}_1$
z
$\mathbf{F}_2$
α
α
$\mathbf{F}_3$
a
$\mathbf{F}_6$
$\mathbf{F}_4$
y
α
a
$\mathbf{F}_5$
a
$\mathbf{W}$
x



$\mathbf{F}_2$
$\mathbf{F}_4$
$\mathbf{F}_6$

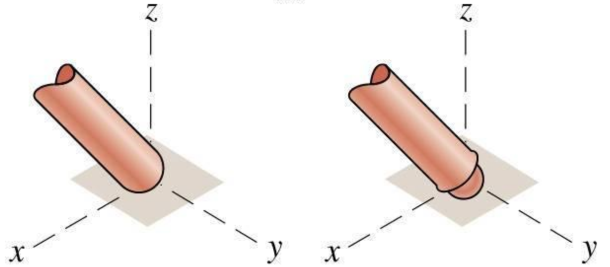


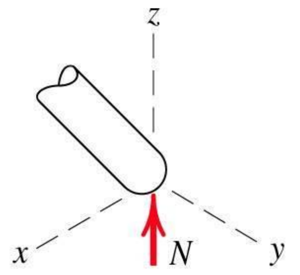
The cube with weight W=24 N and dimensions *a*=1 m is in equilibrium.

Calculate F_1 to F_6.

Constraints in 3 dimensions

1. Member in contact with smooth surface, or ball-supported member



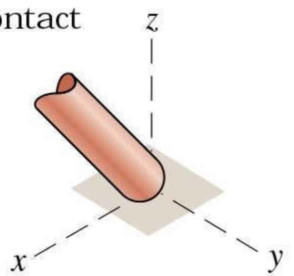


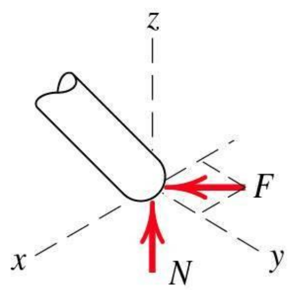
Force must be normal to the surface and directed toward the member.

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

Constraints in 3 dimensions

2. Member in contact with rough surface



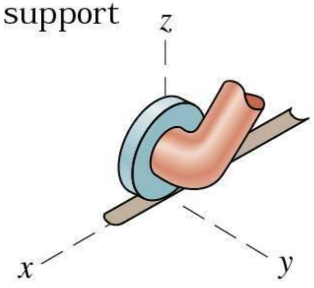


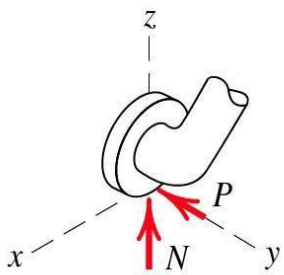
The possibility exists for a force F tangent to the surface (friction force) to act on the member, as well as a normal force N.

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

Constraints in 3 dimensions

3. Roller or wheel support with lateral constraint



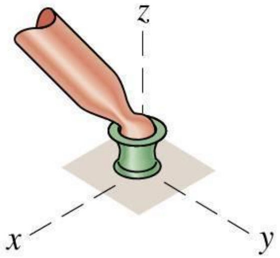


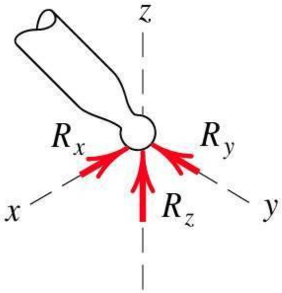
A lateral force P exerted by the guide on the wheel can exist, in addition to the normal force N.

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

Constraints in 3 dimensions

4. Ball-and-socket joint



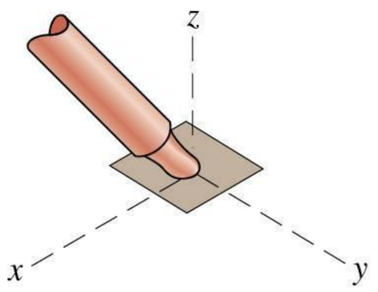


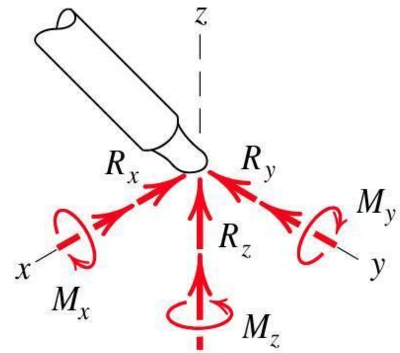
A ball-and-socket joint free to pivot about the center of the ball can support a force **R** with all three components.

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

Constraints in 3 dimensions

5. Fixed connection (embedded or welded)



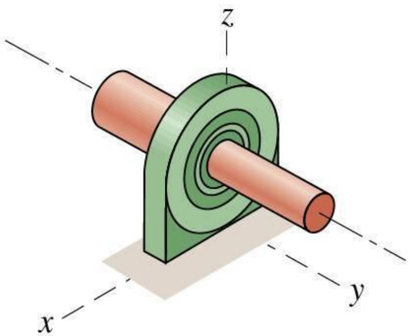


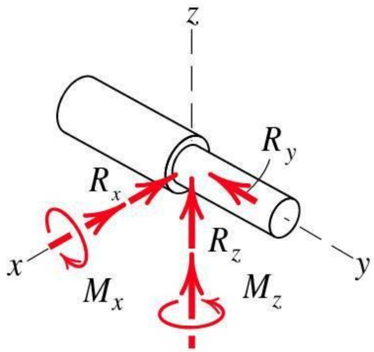
In addition to three components of force, a fixed connection can support a couple **M** represented by its three components.

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

Constraints in 3 dimensions

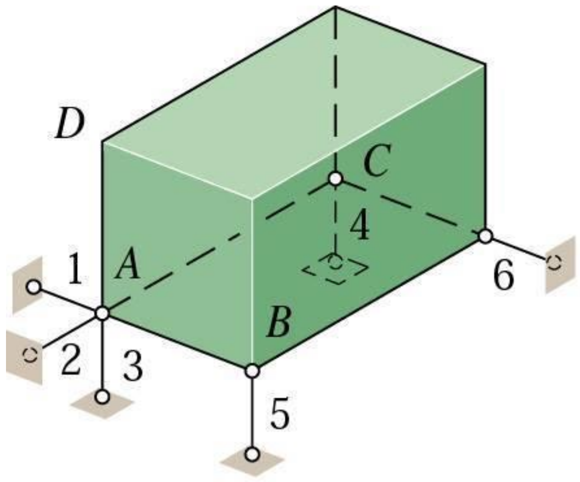
6. Thrust-bearing support



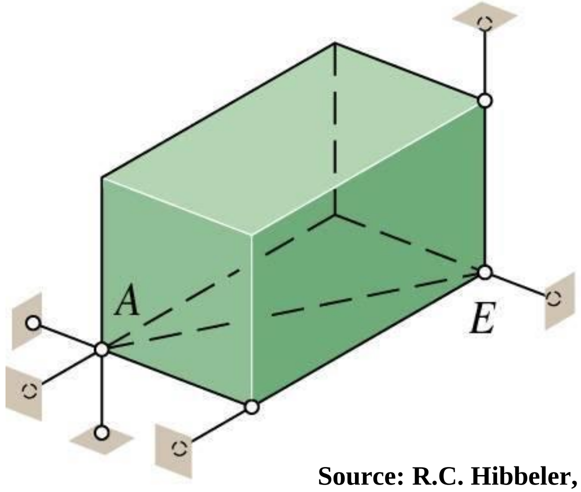


Thrust bearing is capable of supporting axial force R_y as well as radial forces R_x and R_z. Couples M_x and M_z must, in some cases, be assumed zero in order to provide statical determinacy.

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

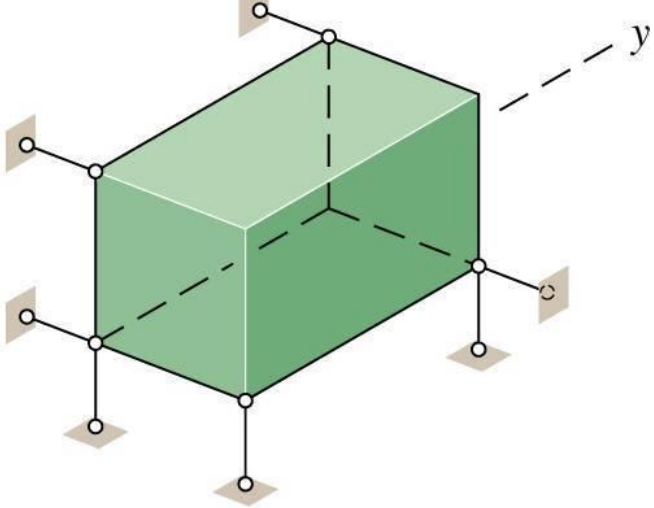


(*a*) Complete fixity
Adequate constraints

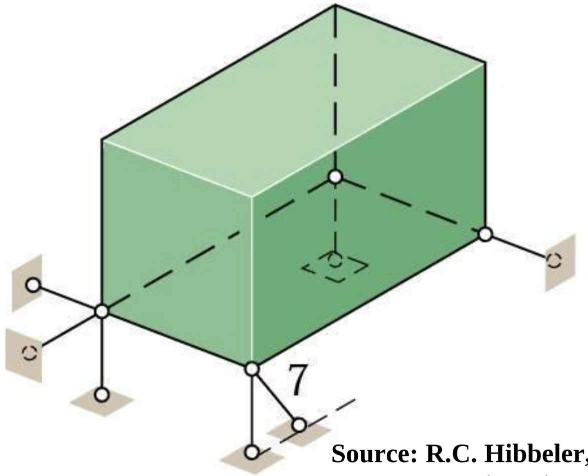


Source: R.C. Hibbeler, "Engineering Mechanics – Statics"

(*b*) Incomplete fixity
Partial constraints

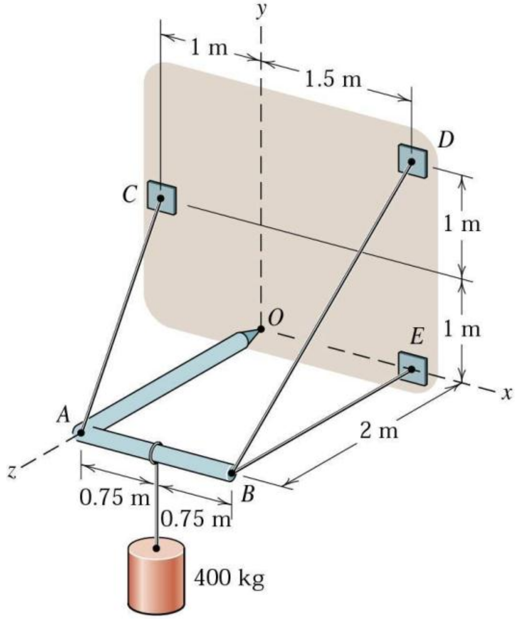


(*c*) Incomplete fixity
Partial constraints



(*d*) Excessive fixity
Redundant constraints

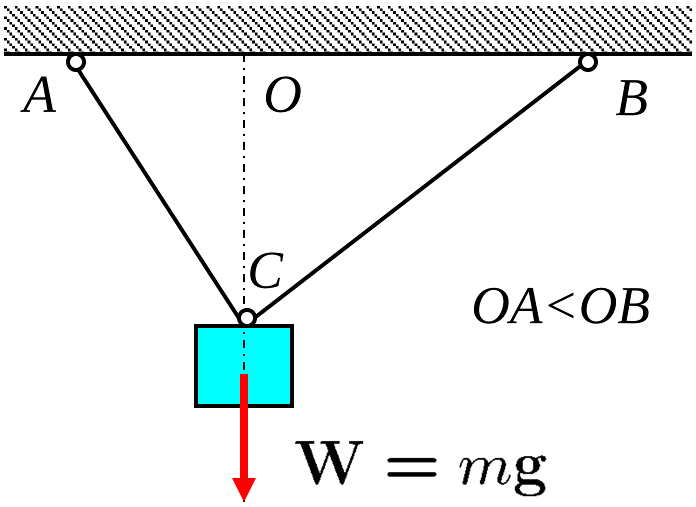
Source: R.C. Hibbeler, "Engineering Mechanics – Statics"



The light right-angle boom which supports the 400-kg cylinder is supported by three cables and a ball- and socket joint at *O* attached to the vertical *x*-*y* surface.

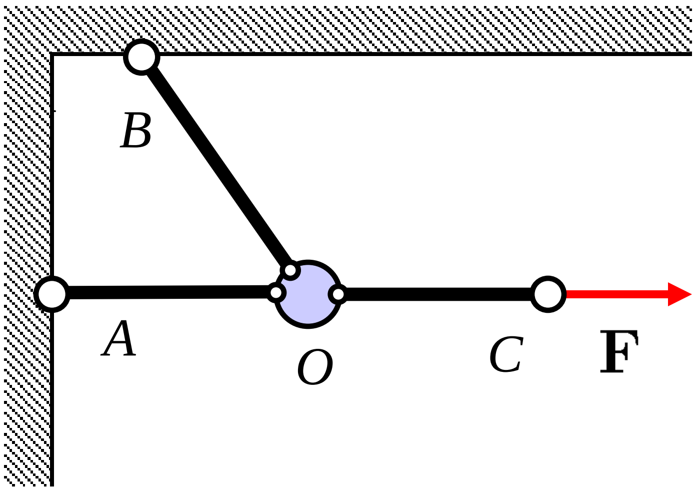
Determine the reactions at *O* and the cable tensions.

Source: R.C. Hibbeler, "Engineering Mechanics – Statics"



A particle is subjected to its own weight and is kept in equilibrium by two cables *AC* and *BC*. The tension in the cables are denoted T_{AC} and T_{BC} respectively. Which of the following statements is true?

A) $T_{AC} < T_{BC}$
B) $T_{AC} > T_{BC}$
C) $T_{AC} = T_{BC}$



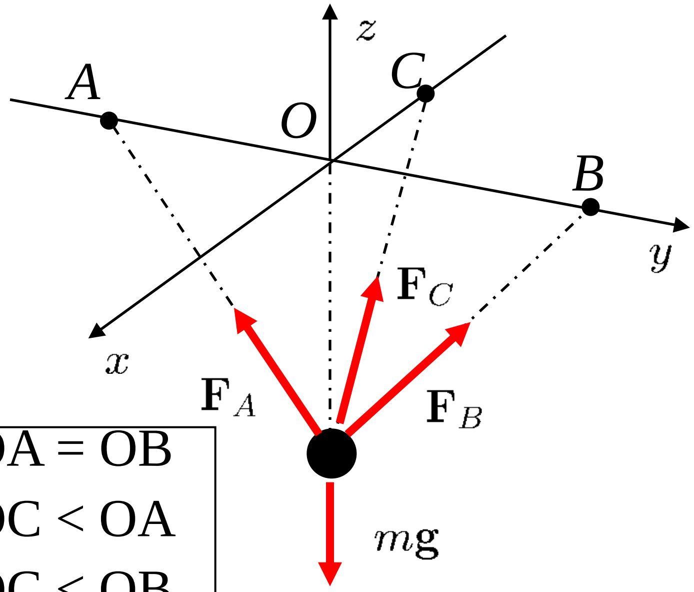
Consider the following experimental set-up in the International Space Station (no gravity!!!). Particle *O* is connected to 3 bars (links). Bar OC is subjected to a force **F.** Which of the following statements is true?

A) *OA* is loaded in compression

B) $T_{OA} = T_{OB}$

C) $T_{OB} = 0$

D) $T_{OC} > T_{OA}$



OA = OB

OC < OA

OC < OB

A particle is subjected to its own weight and is kept in equilibrium by three forces with magnitude F_A, F_B and F_C. Points A and B are on the *y*-axis and *C* is on the *x*-axis. Which of the following is true?

A) $F_C > mg$

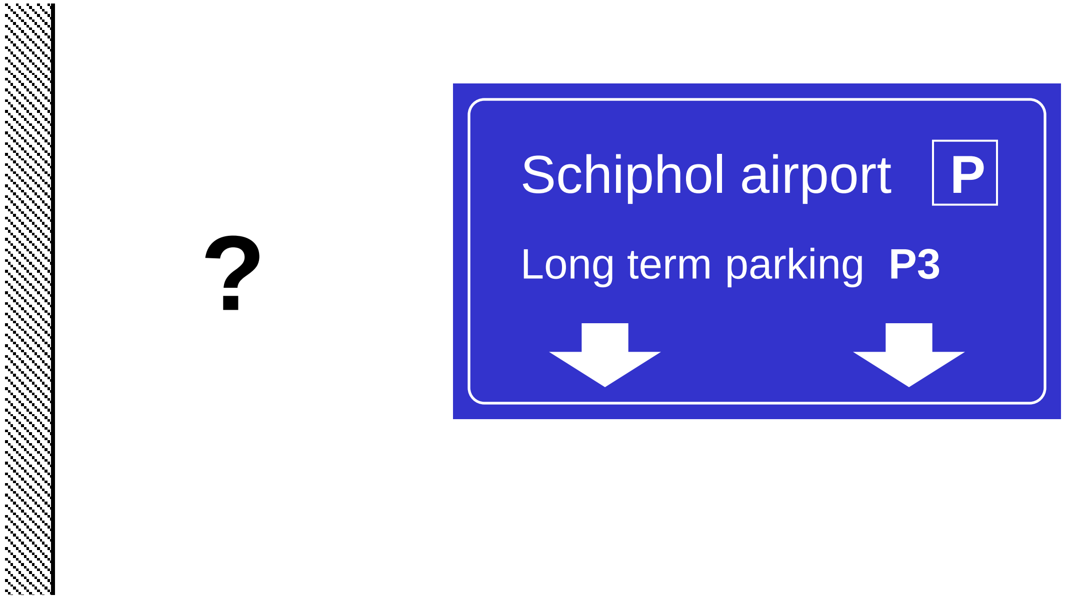
B) $F_C > F_A$ and $F_C > F_B$

C) $F_A + F_B = 0$

D) $F_C = 0$

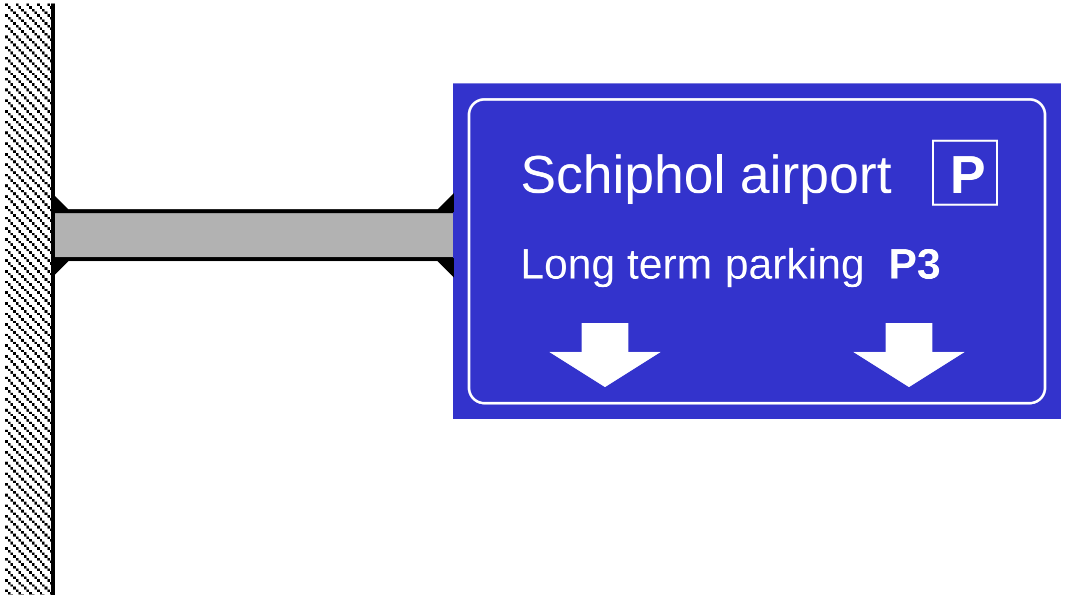
Design exercise

Design an efficient (=low weight) structure to attach the road sign to the wall. Take into account that the sign has a considerable mass and is subject to wind loads.



Design exercise

Design a structure to attach the road sign to the wall.



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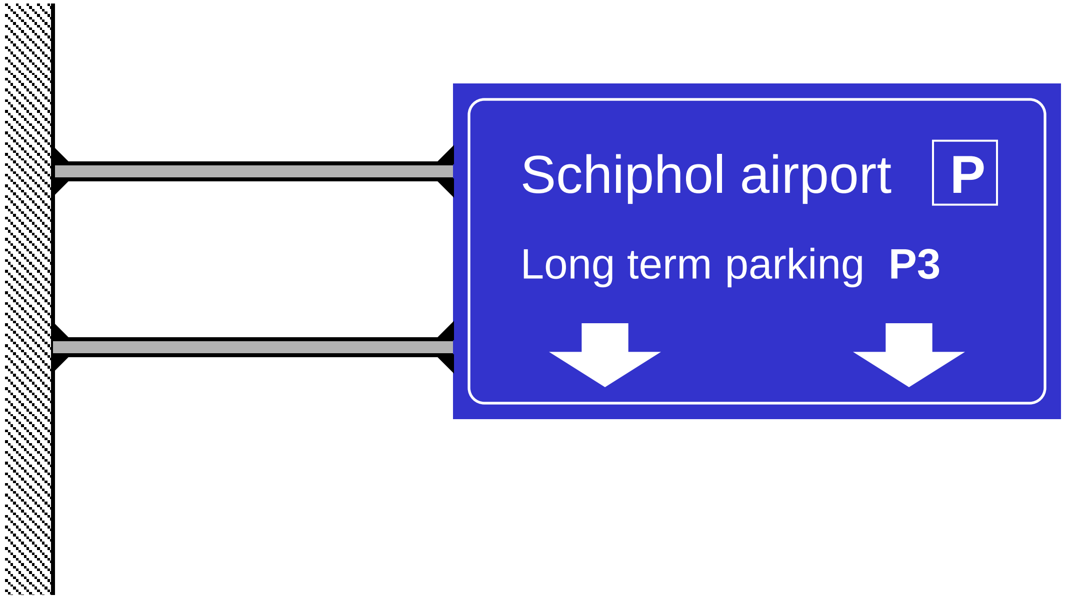
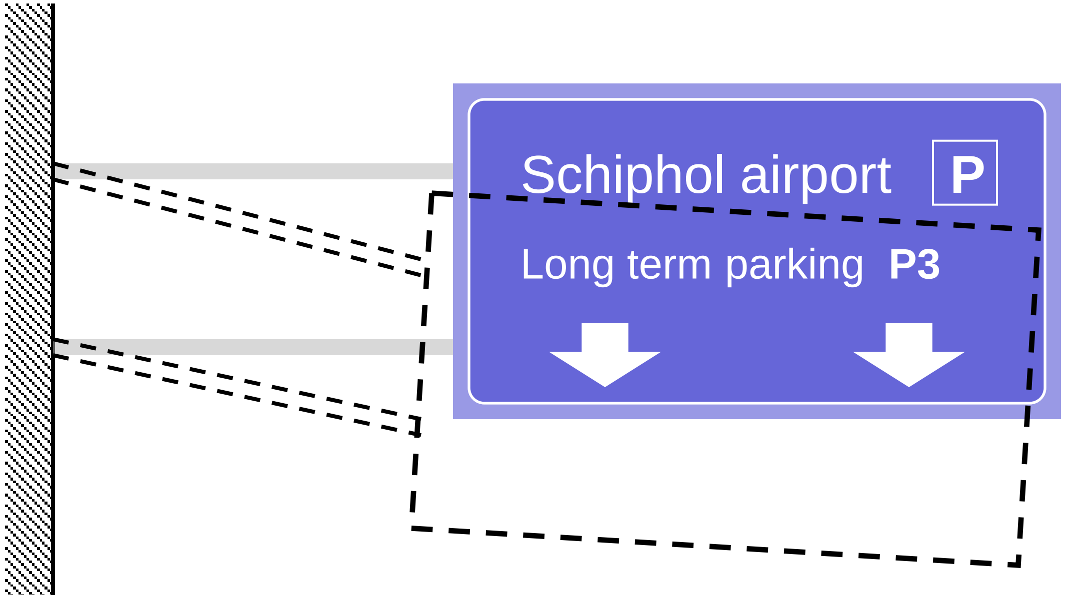


Design exercise

Design a structure to attach the sign to the wall.



Design exercise

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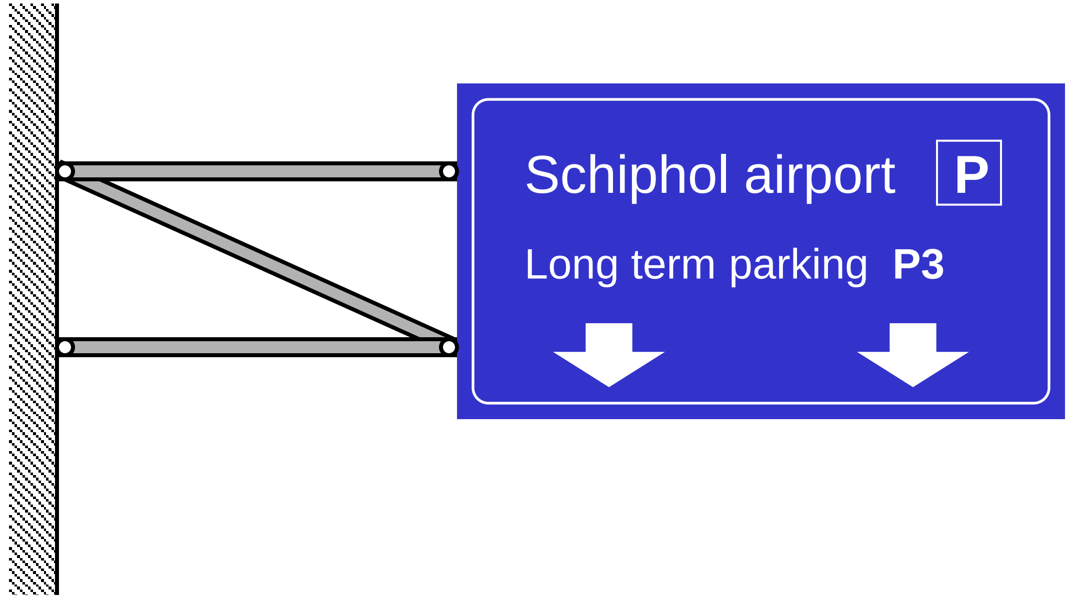
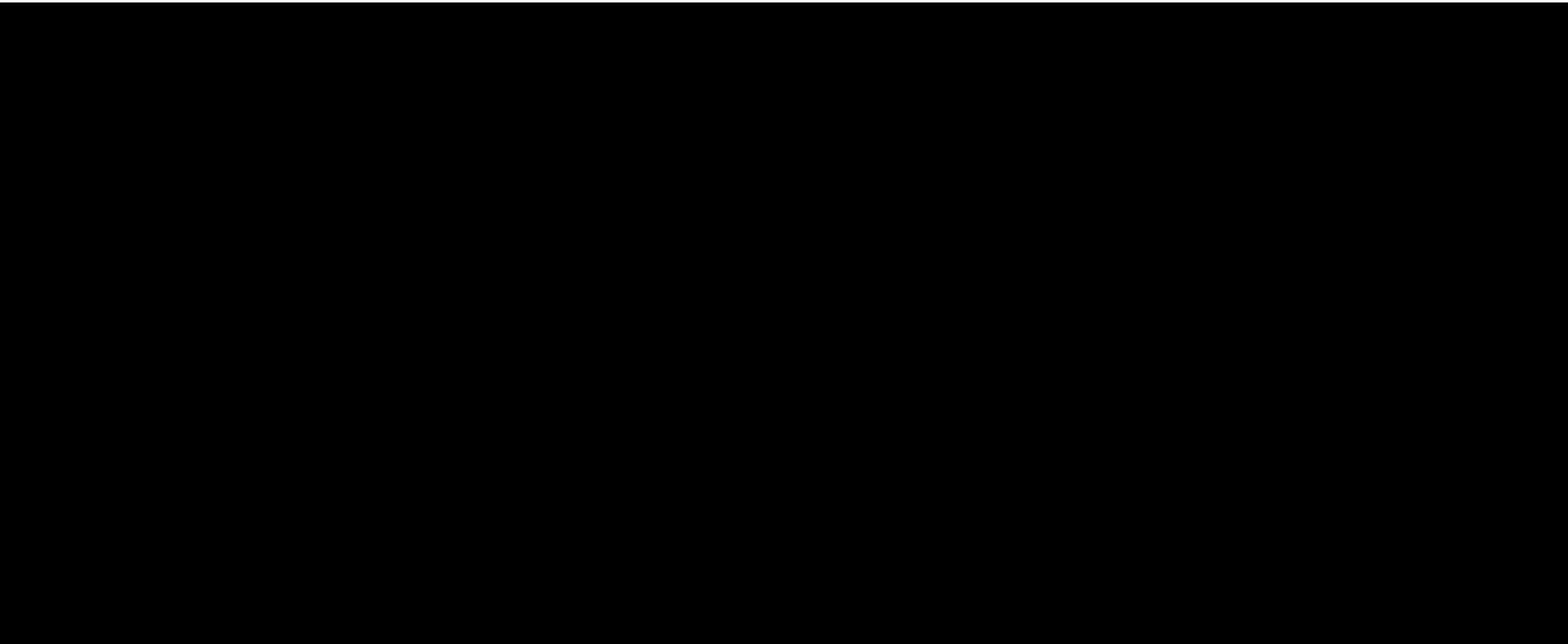


Truss structure

A framework composed of members joined at their ends to form a rigid structure

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LEGENDS
show


Gulf
007
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BANQUE
BARING BROTHERS
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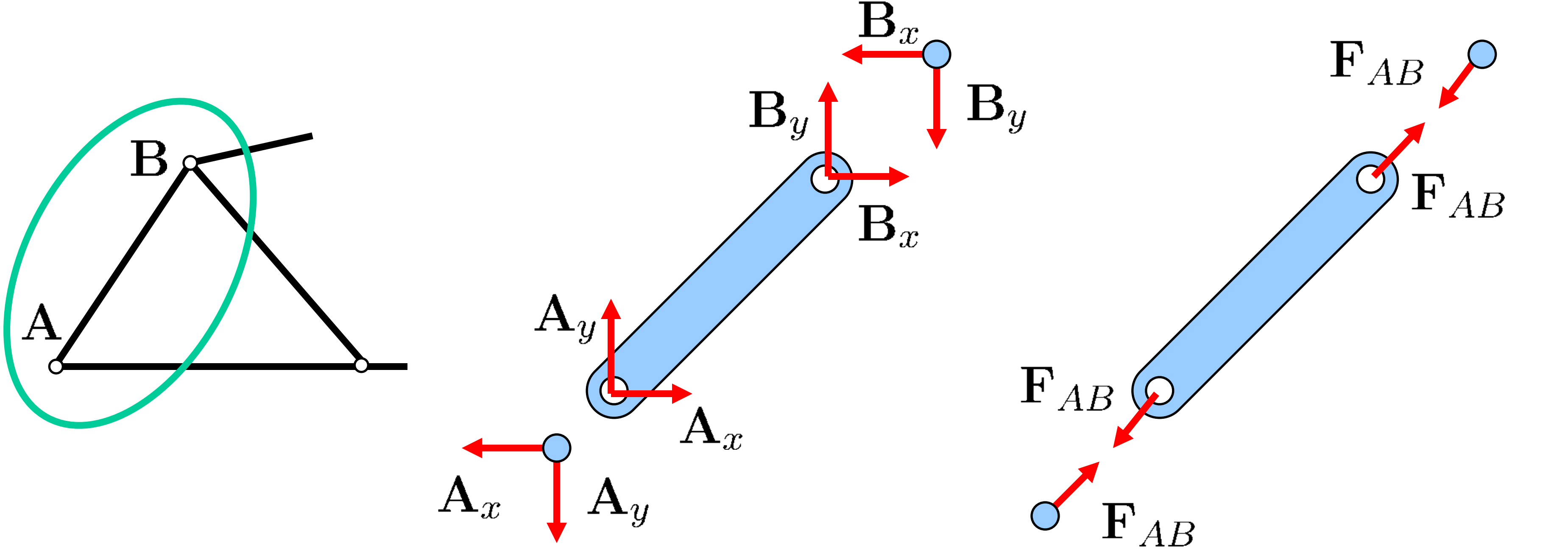
BARING BROTHERS
STURDZA
MICHELIN

Model of a truss structure

- All members are connected by pin joints (even when in reality, the members are connected by welding or riveting).

- All external forces are applied at the pin connections.

- All members are assumed to be straight.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