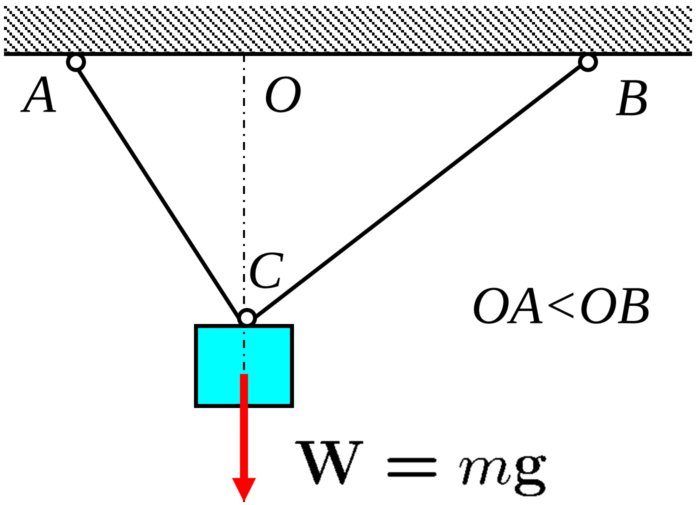
Today:

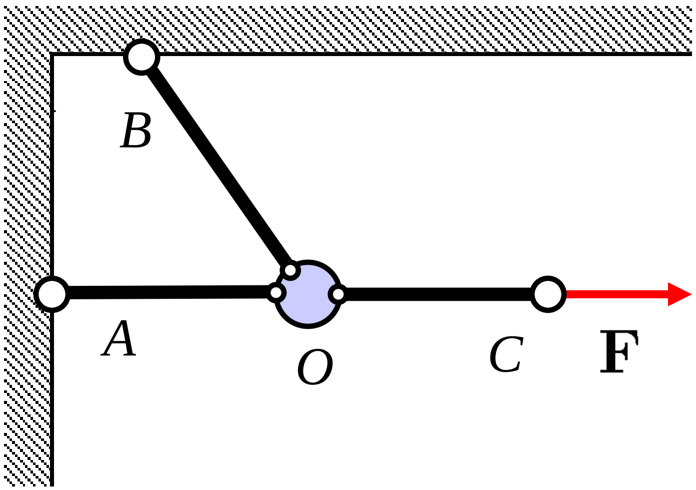
Trusses

Book: Chapter 6.1-6.3



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) $T_{AC} = T_{BC}$



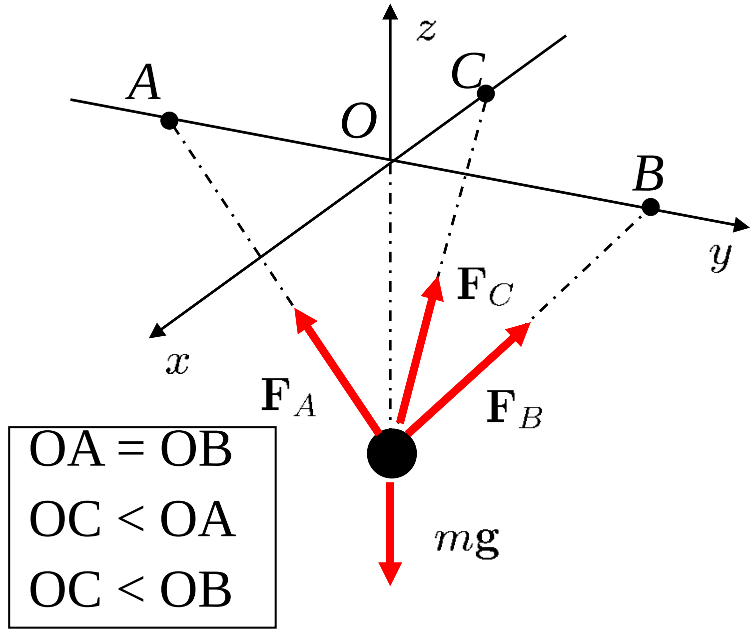
Consider the following experimental set-up in the International Space Station (no gravity!!!). Particle *O* is connected to 3 bars (links). Bar OC is subjected to a force **F.** Which of the following statements is true?

A) *OA* is loaded in compression

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

C) $T_{OB} = 0$

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



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) $F_C > mg$

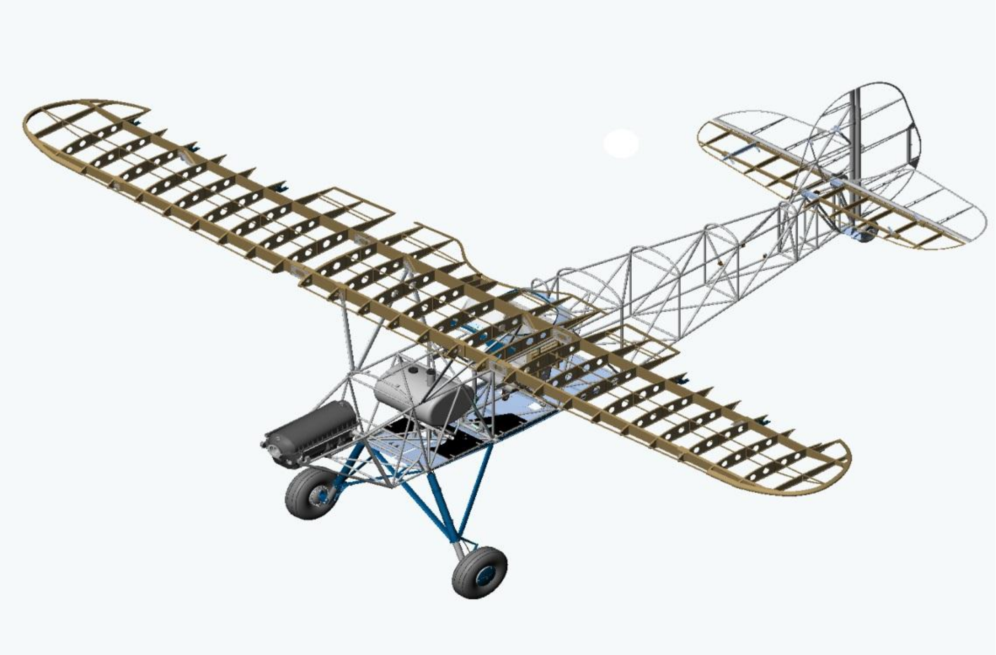
B) $F_C > F_A$ and $F_C > F_B$

C) $F_A + F_B = 0$

D) $F_C = 0$

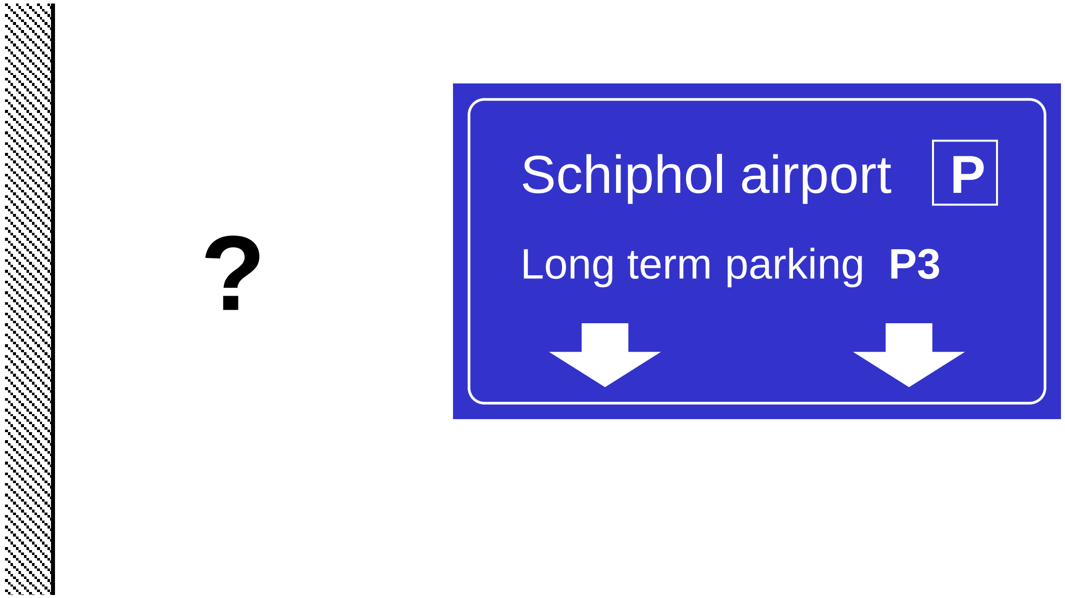
Model of a truss structure

- 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.



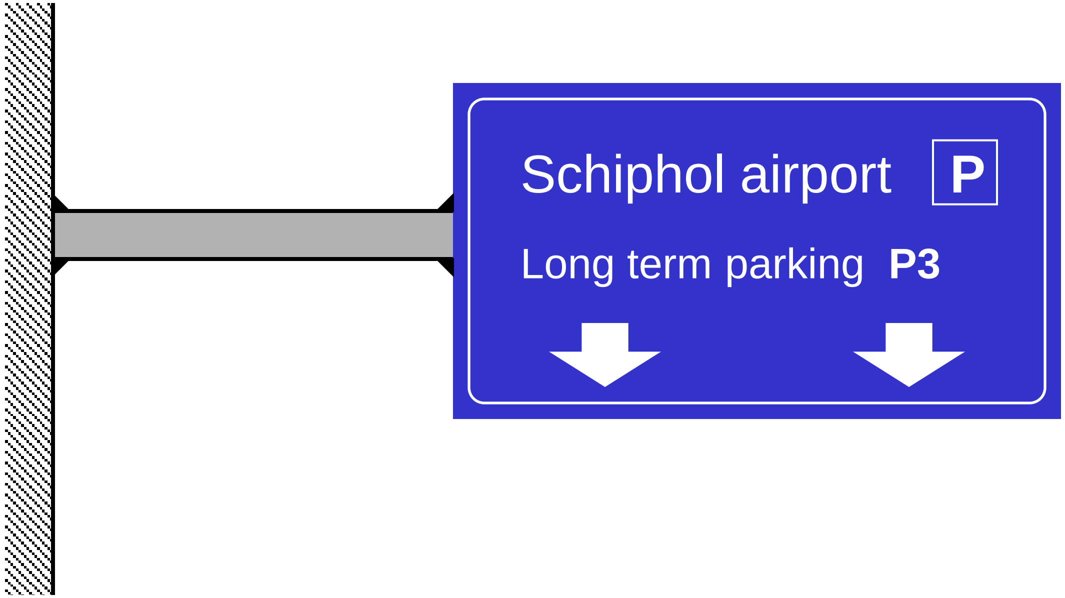
Design exercise

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.



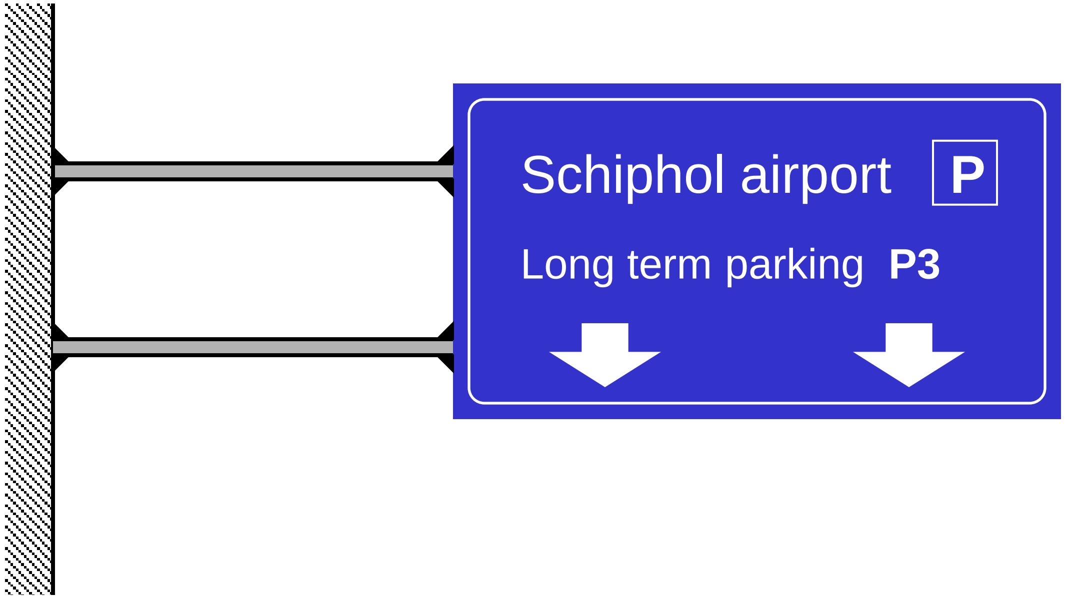
Design exercise

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



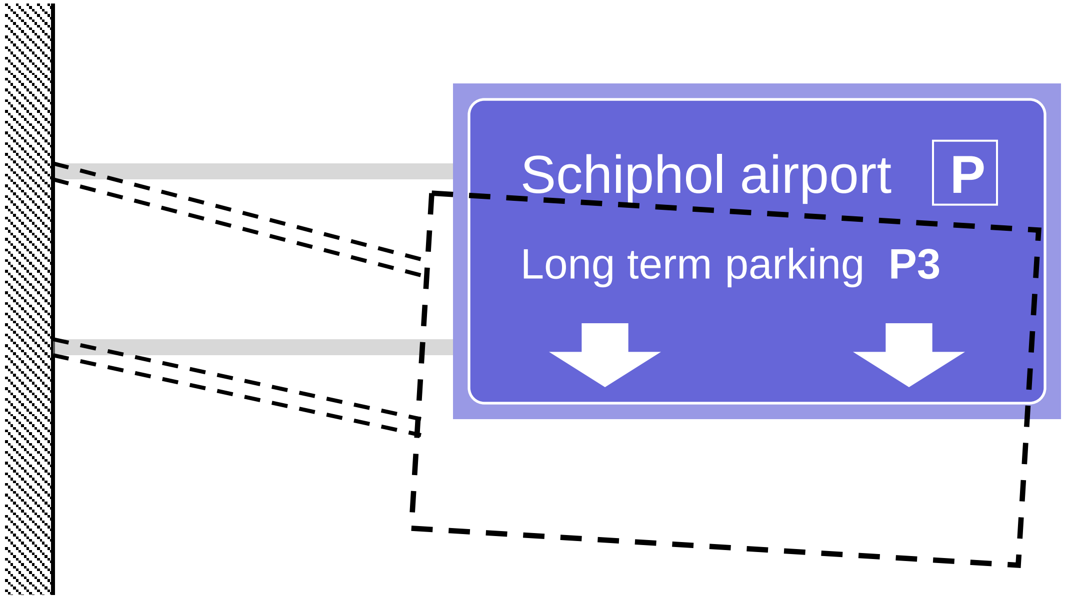
Design exercise

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



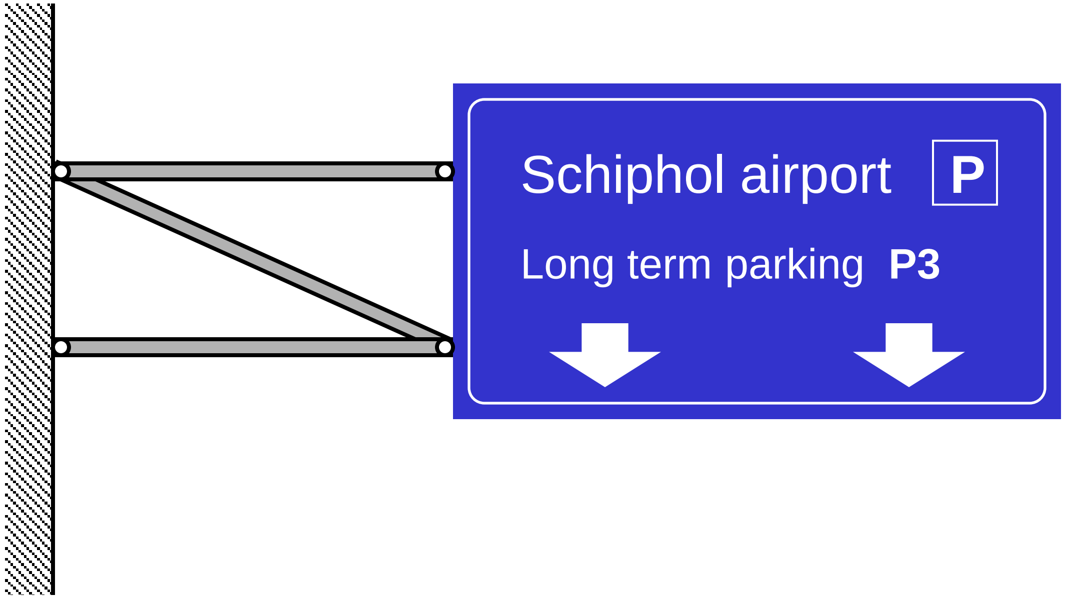
Design exercise

Design a structure to attach the sign to the wall.



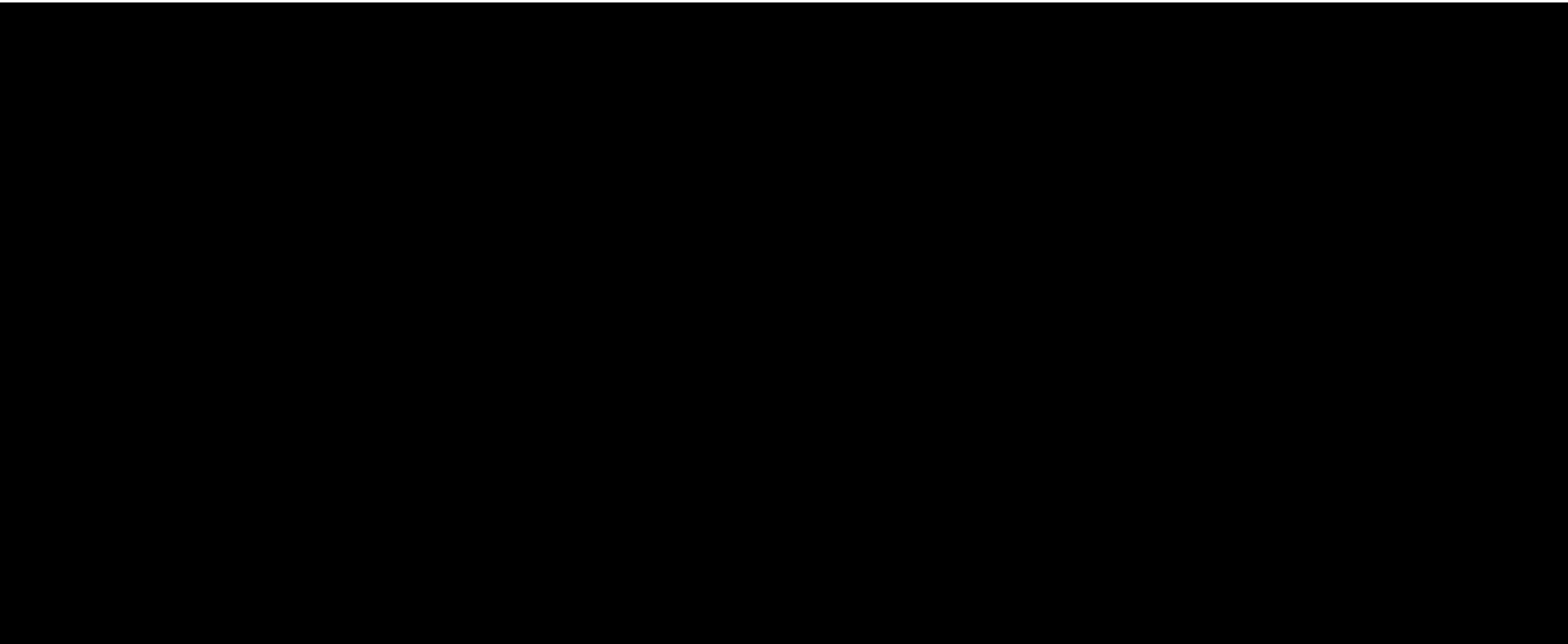
Design exercise

Design a structure to attach the sign to the wall.

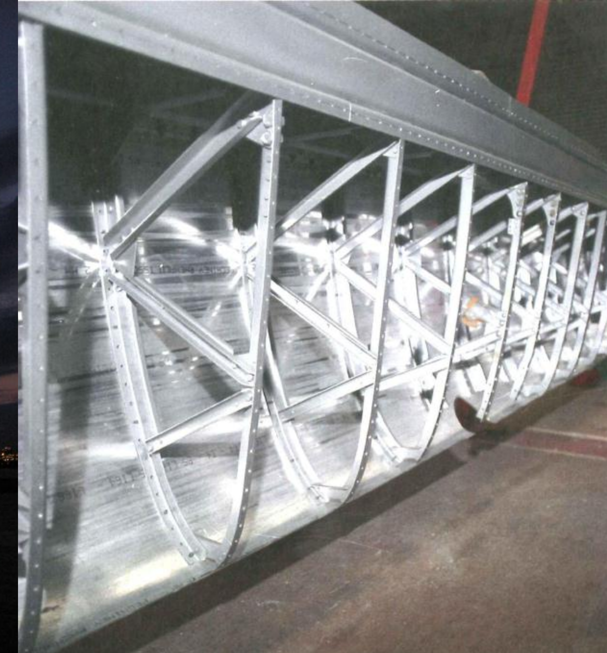


Truss structure

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




NDAY 12 JULY 2009
LEGENDS
show



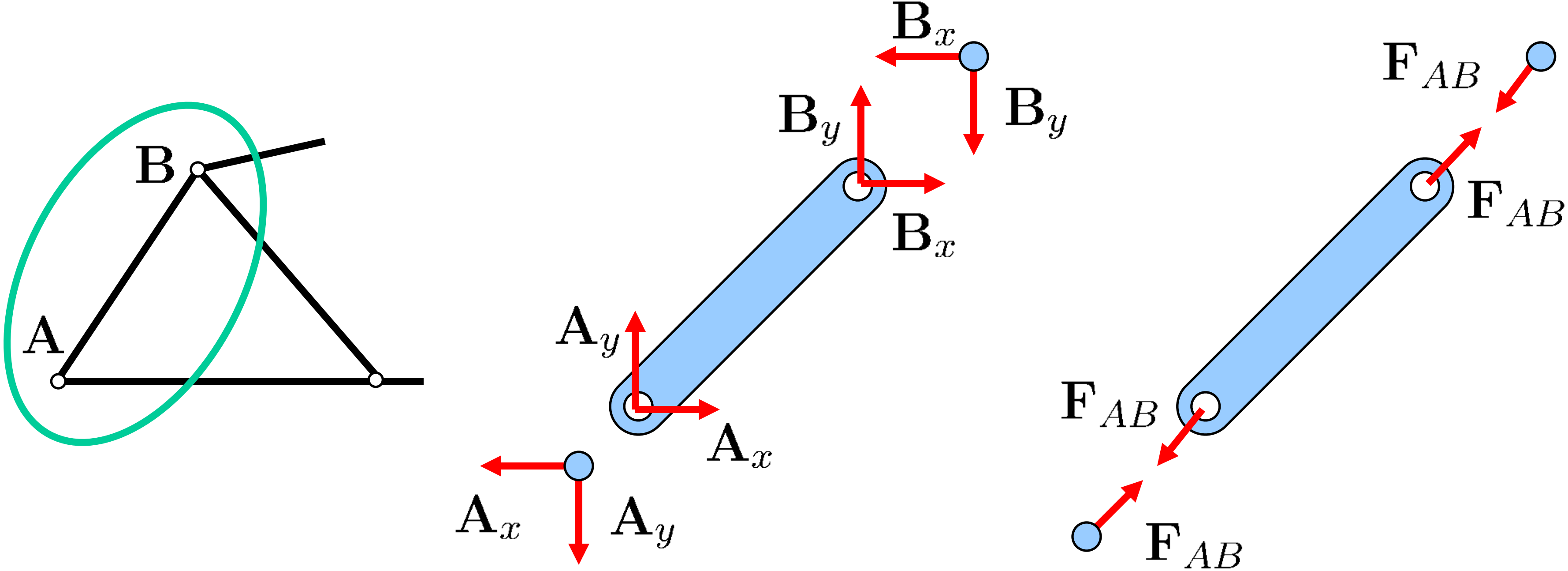

Gulf
zepter
BANQUE
BARING BROTHERS
STURDZA
007
zepter
BANQUE
BARING BROTHERS
STURDZA
MICHELIN

Model of a truss structure

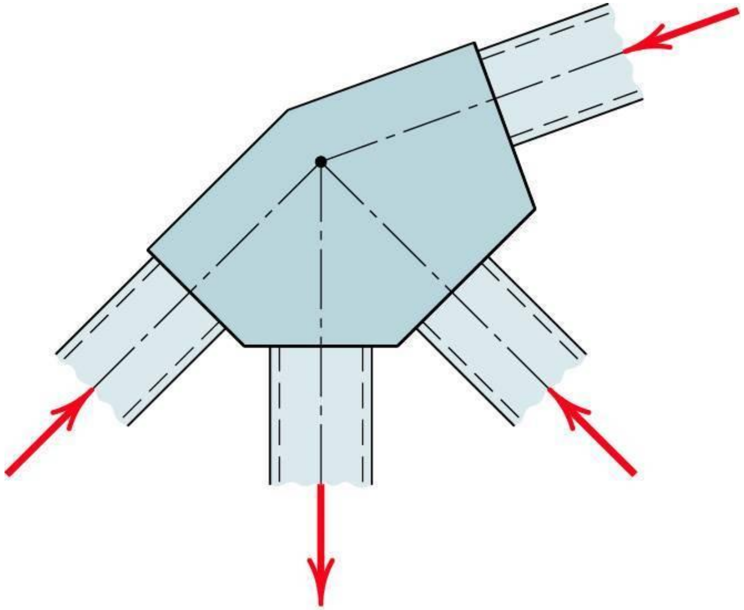
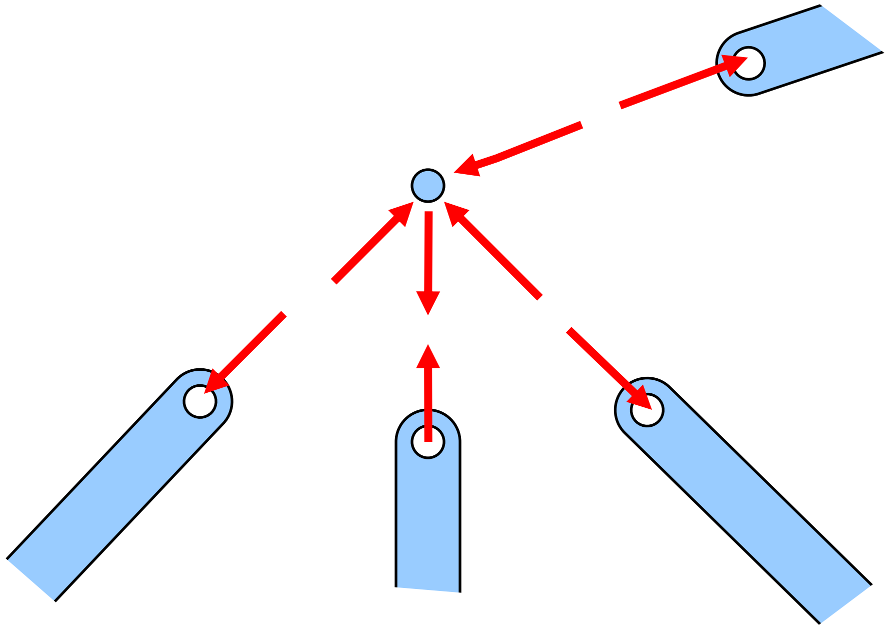
- All members are connected by pin joints (even when in reality, the members are connected by welding or riveting).

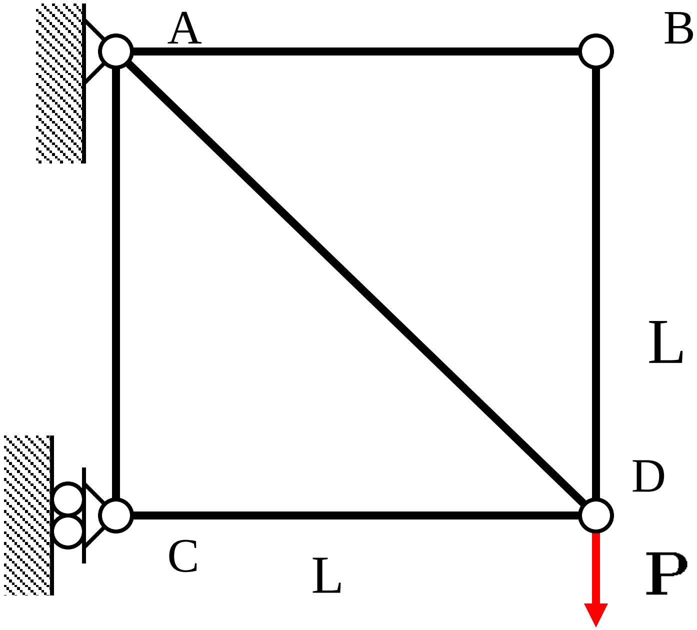
- All external forces are applied at the pin connections.

- All members are assumed to be straight.

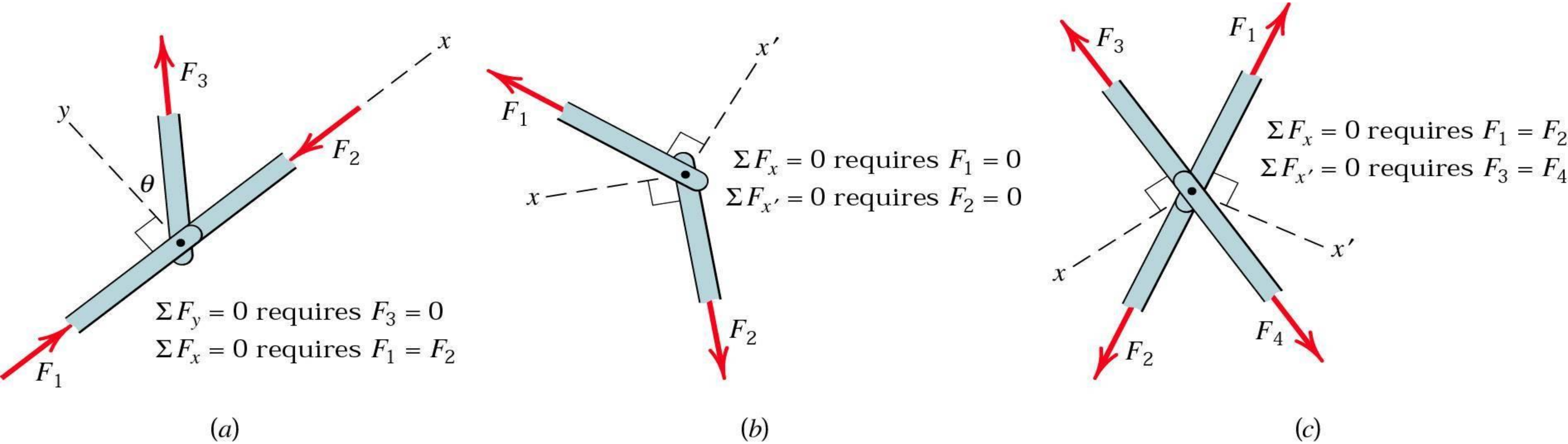


B
A
$\mathbf{B}_x$
$\mathbf{B}_y$
$\mathbf{B}_y$
$\mathbf{B}_x$
$\mathbf{A}_y$
$\mathbf{A}_x$
$\mathbf{A}_x$
$\mathbf{A}_y$
$\mathbf{F}_{AB}$
$\mathbf{F}_{AB}$
$\mathbf{F}_{AB}$
$\mathbf{F}_{AB}$

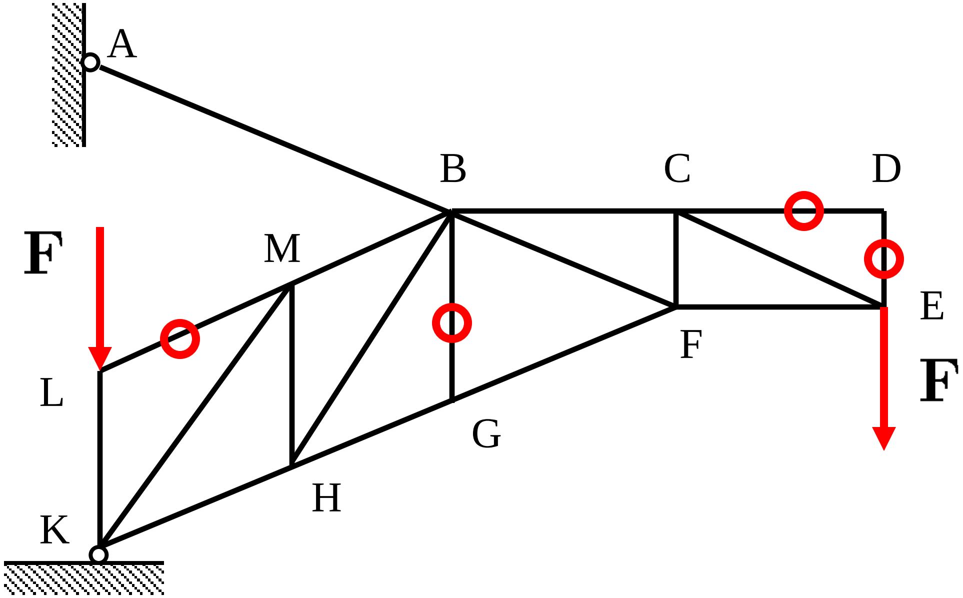


Calculate the forces in all the members.

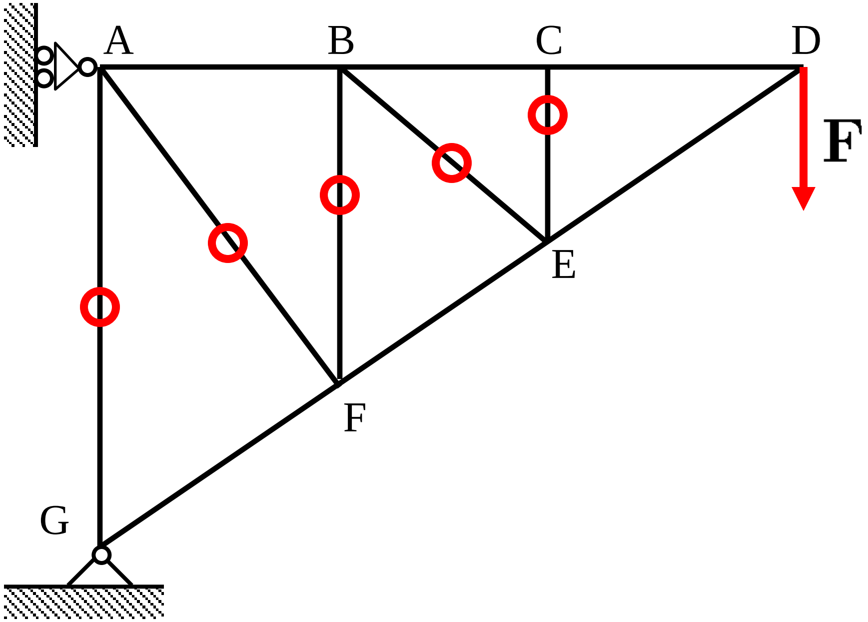


Source: R.C. Hibbeler,

"Engineering Mechanics – Statics"

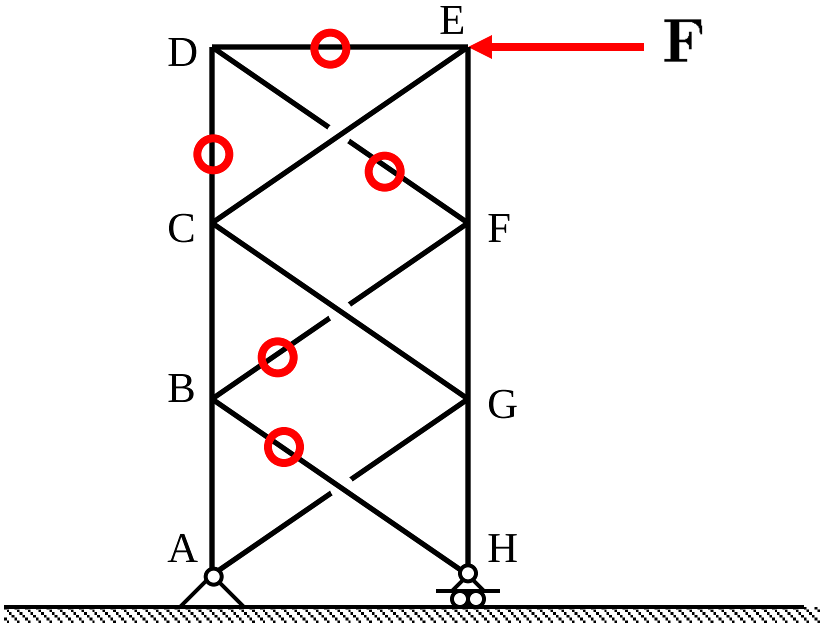


Determine the zero-force members of this structure under the given load.



How many zero-force members does this structure have for the given external load?

A) 0
B) 1
C) 4
D) 5



How many zero-force members does this structure have for the given load?

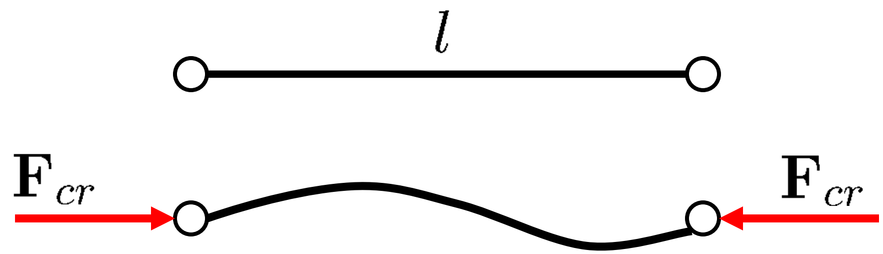
A) 0
B) 3
C) 5
D) 7

What are zero-force members good for?

- In case the structure is loaded in a different way

- To prevent buckling

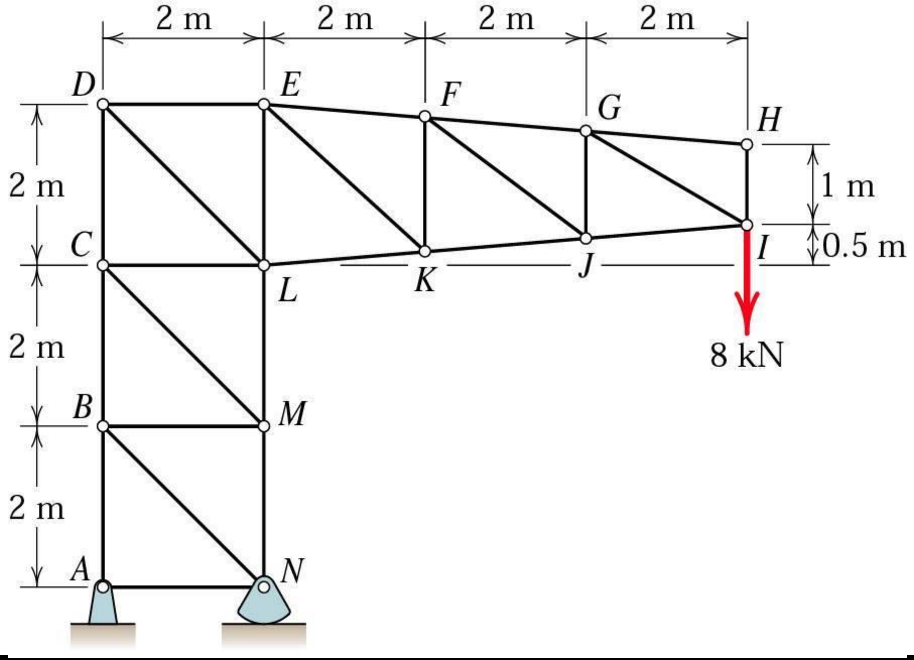
$$\mathbf{F}_{cr} \propto 1/l^2$$



Method of joints

Determine the force in the members by calculating the equilibrium of the joints

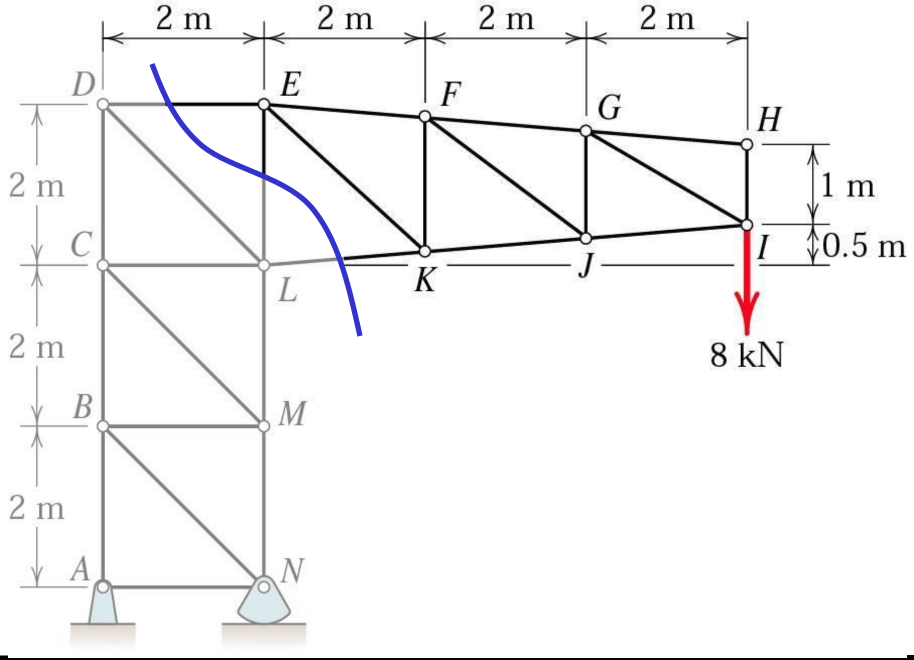
1. Draw Free Body Diagram
2. Determine the reaction forces at the supports of the whole structure
3. Calculate the forces in a joint with max. 2 unknowns
4. Proceed to the next joint with max. 2 unknowns until all joints are analyzed



Determine the force in member DE.

Source: R.C. Hibbeler,

"Engineering Mechanics – Statics"



1) Determine the force in member DE.

2) Determine the force in member DL.

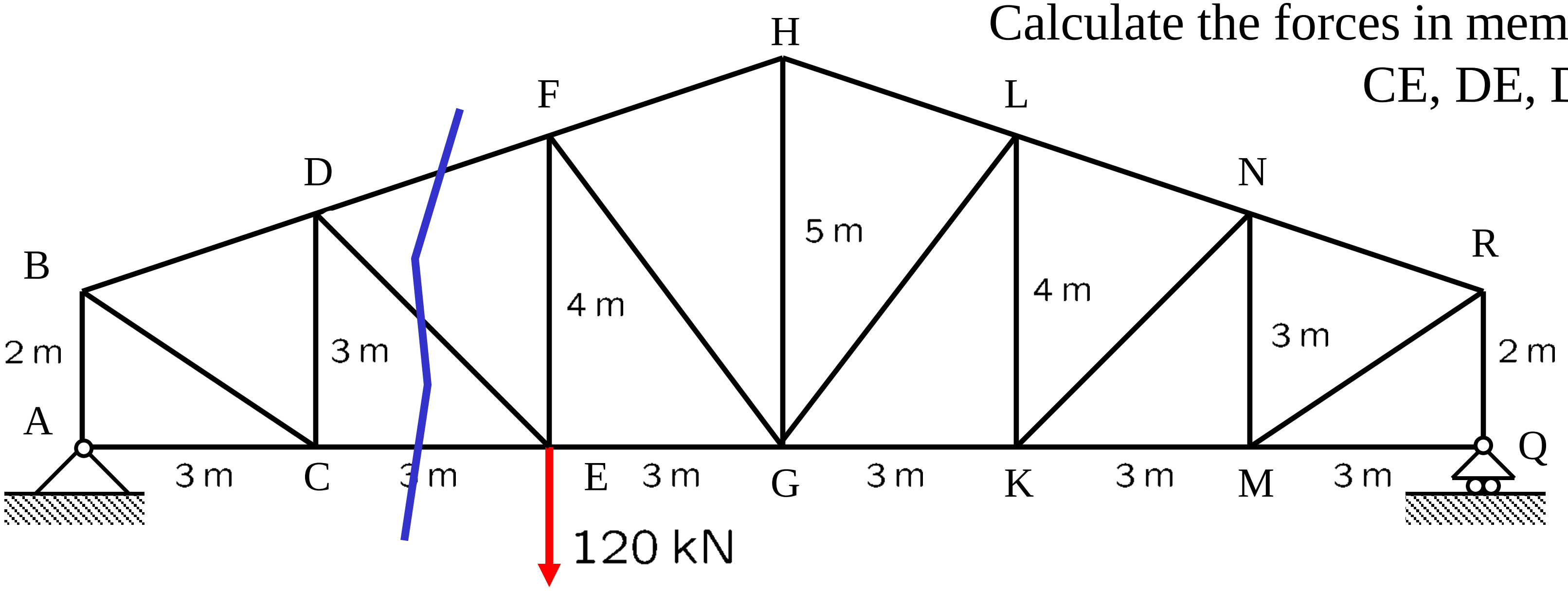
Method of sections

Determine the force in a members by dividing the structure in two sections by cutting the members and calculating the equilibrium of one of the sections.

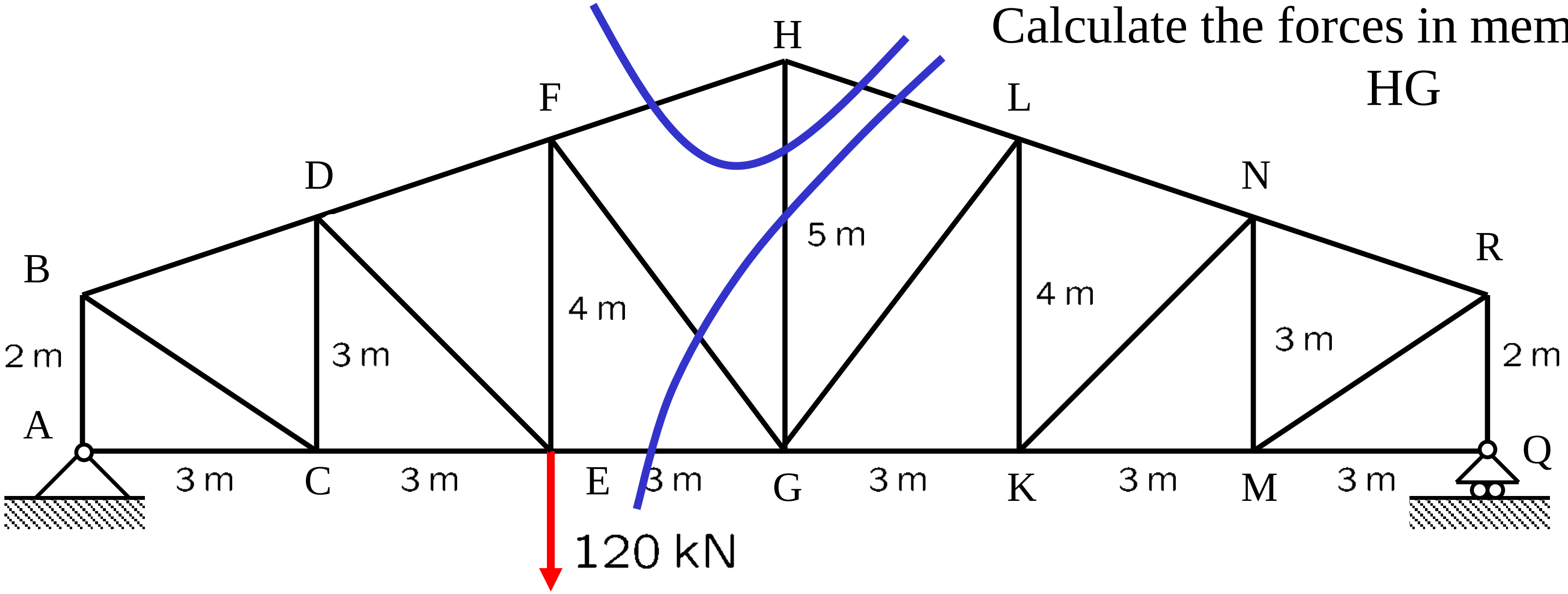
1) Determine the section by cutting just three members (in general)

2) Use the moment equilibrium equation in a clever way.

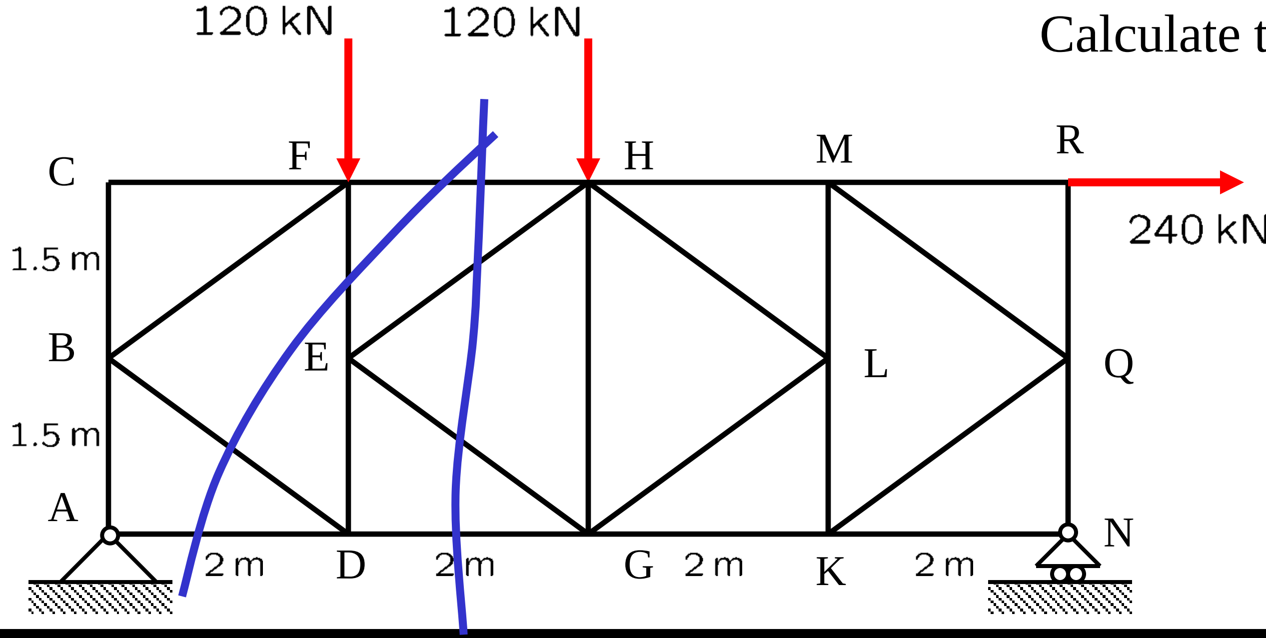
Calculate the forces in members CE, DE, DF



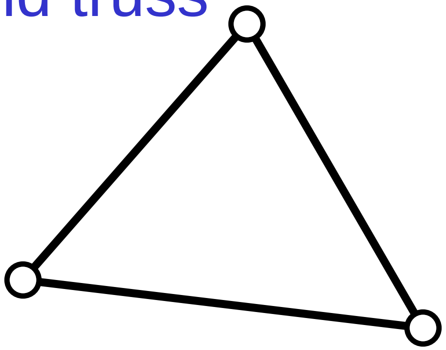
Calculate the forces in member HG



Calculate the forces in member EH

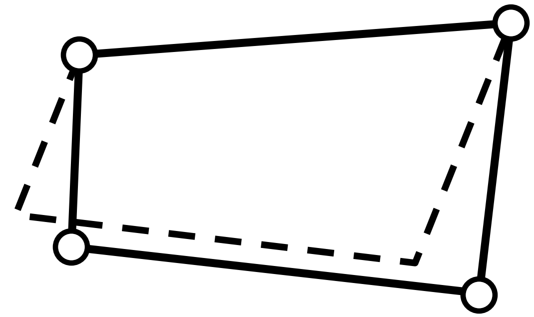


Rigid truss

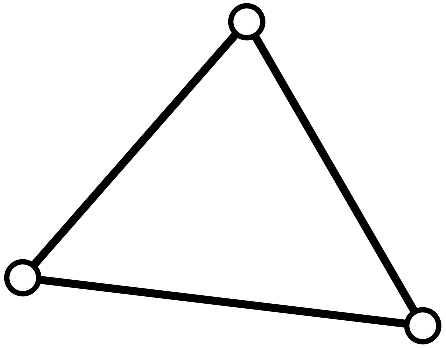


3 members, 3 joints

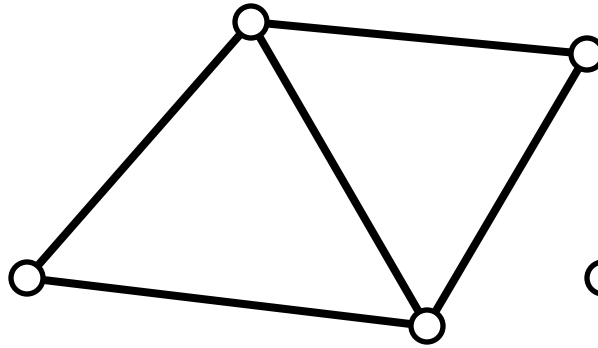
Flexible truss (mechanism)



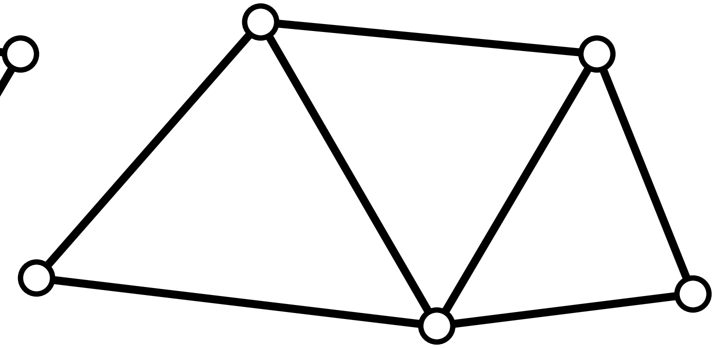
4 members, 4 joints



3 members, 3 joints



5 members, 4 joints



7 members, 5 joints

Rigid truss consisting of triangular elements

$$s = 2k - 3$$

Where

s = number of members

k = number of joints

Non-rigid truss

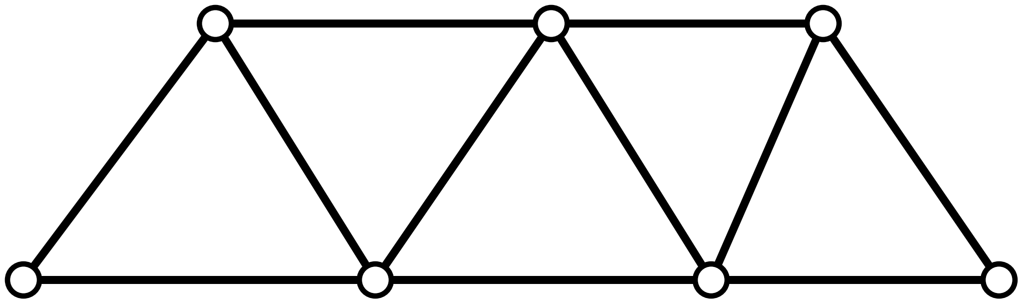
$$s < 2k - 3$$

Rigid truss

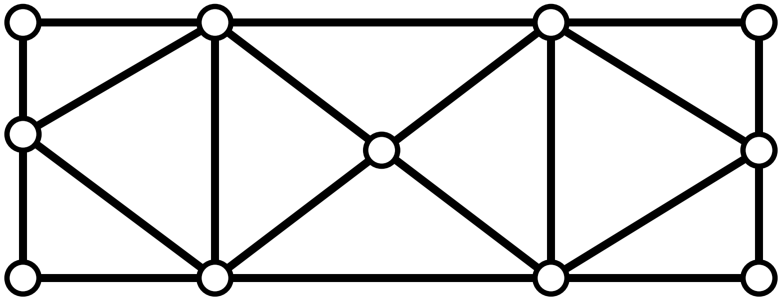
$$s \geq 2k - 3$$

This is a *necessary* condition, but not *sufficient*!!

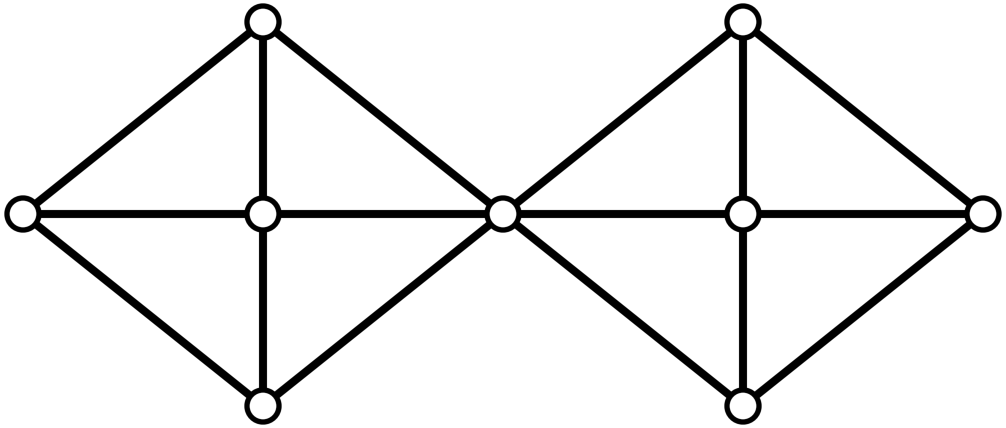
Rigid or non-rigid?



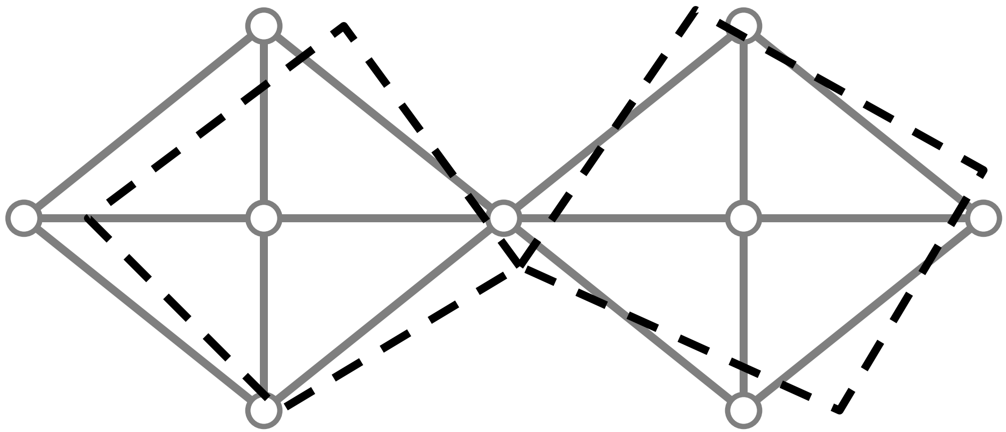
Rigid or non-rigid?



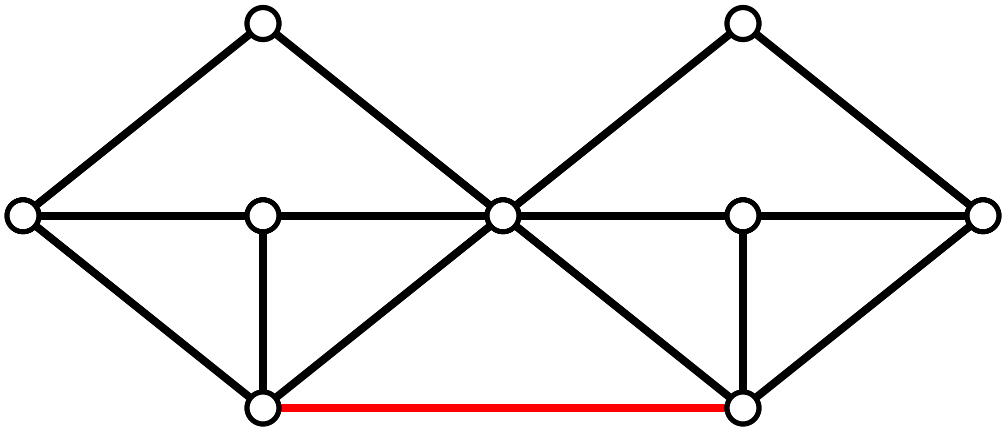
Rigid or non-rigid?



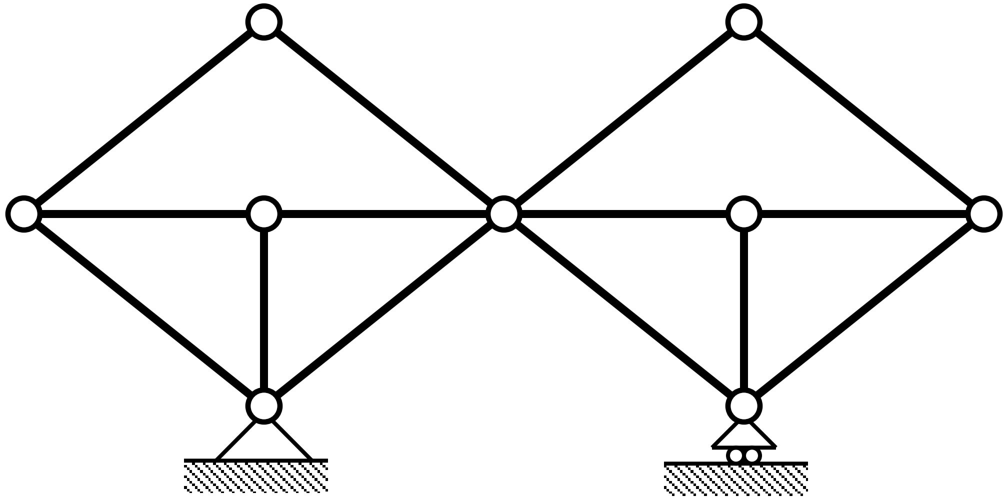
Rigid or non-rigid?



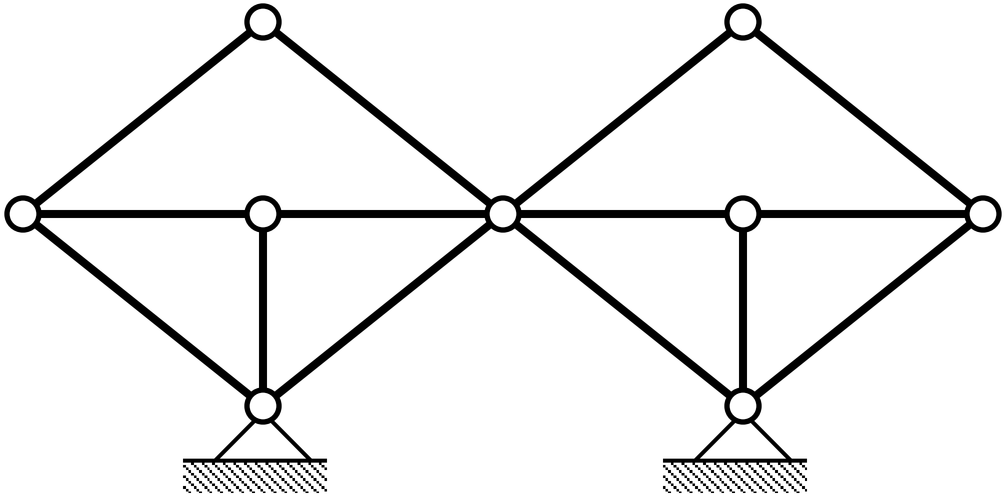
Rigid or non-rigid?



Constraints



Constraints



Constraint truss structure

$$n = r + s - 2k$$

Where

n = difference between number of unknowns and equations

r = number of constraints

s = number of members

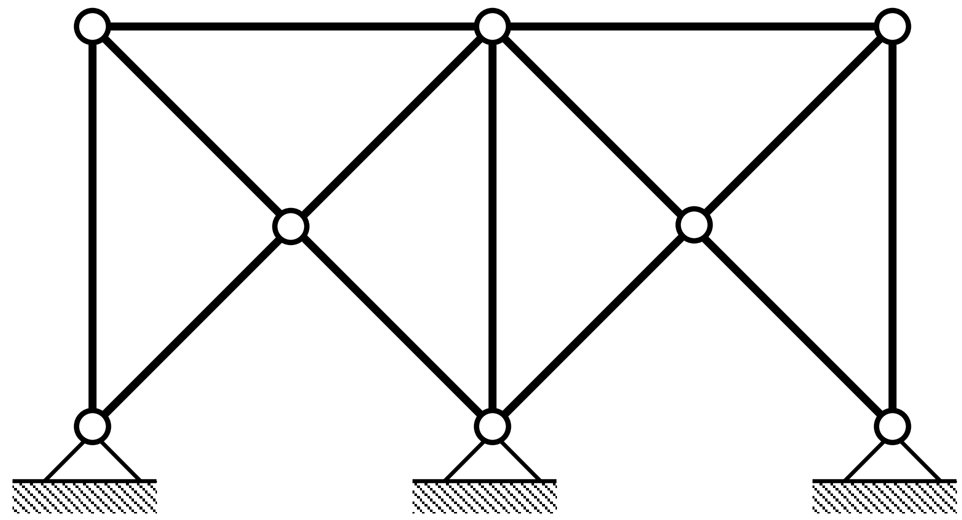
k = number of joints

Constraint truss structure

$$n = r + s - 2k$$

n < 0	kinematically indeterminate (mechanism)
n >= 0	kinematically determinate (necessary, not sufficient)
n = 0	statically determinate
n > 0	statically indeterminate

Statically determinate?

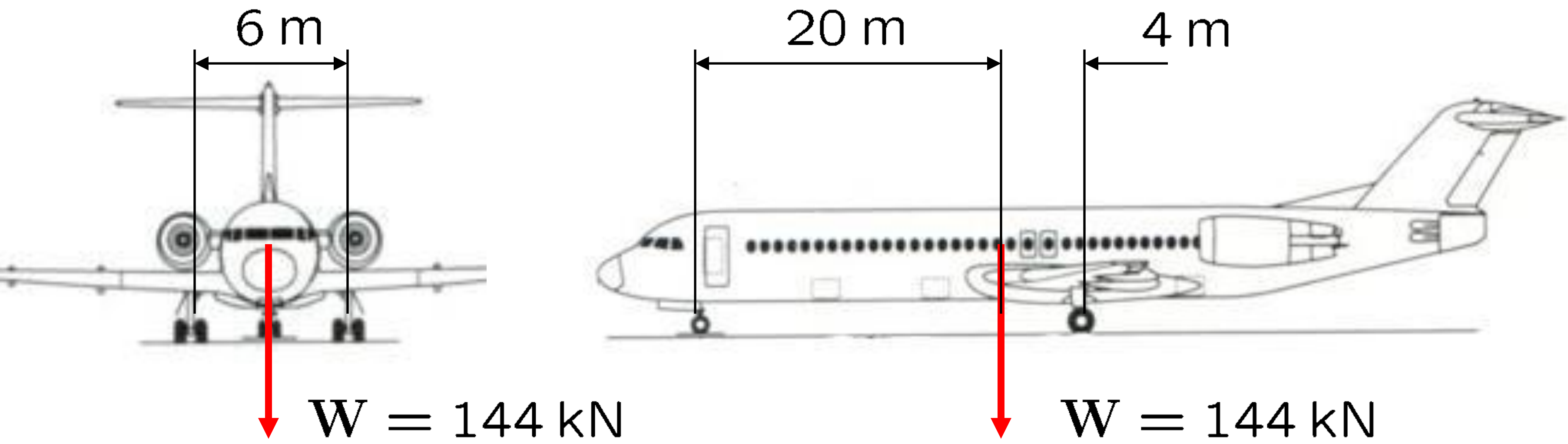


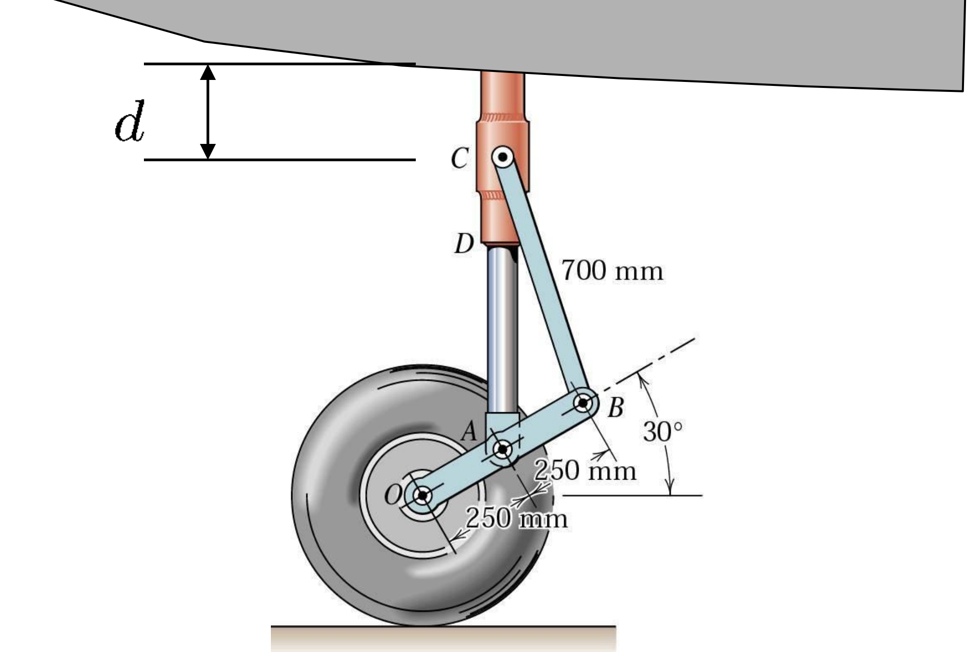
Exercises

Problems: 9.13, 9.83, 9.84, 9.85, 9.25,9.2, 9.3, 9.78

Test: Problem 2 , Statics exam, Jan 9 2003.

Chapter: 9


6 m
W = 144 kN
20 m
4 m
W = 144 kN



Calculate the reaction forces in hinge A when the normal reaction force on the nose wheel from the previous example is 24 kN.

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