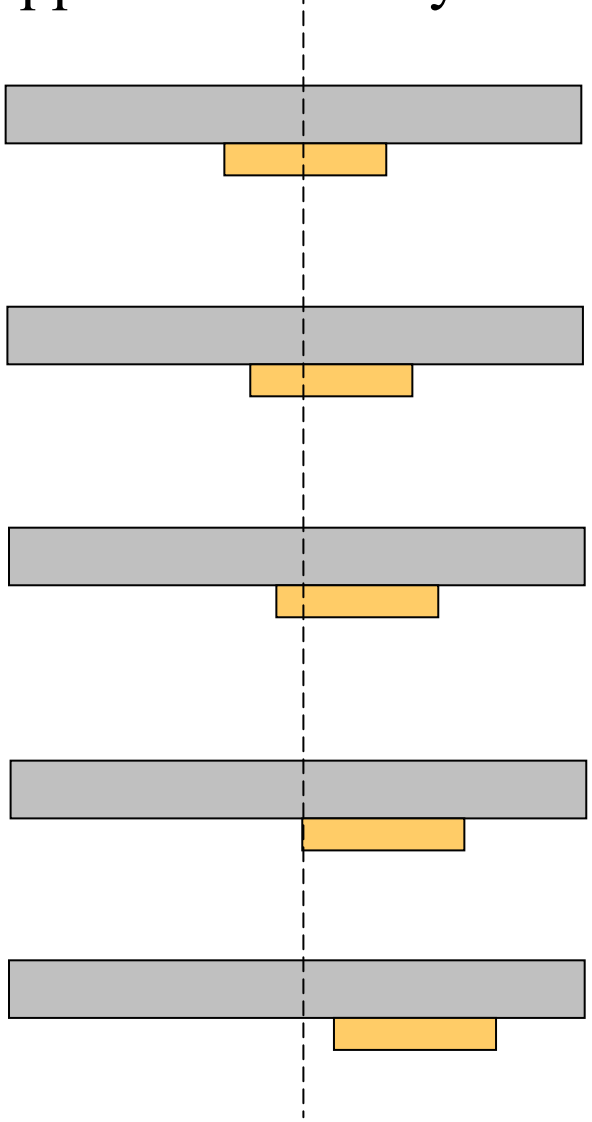
Nonuniform Contact

Support member by resting it on your hand located at various positions



Are you able to keep the member in equilibrium regardless of position of your hand?

Yes Gr

No Pi

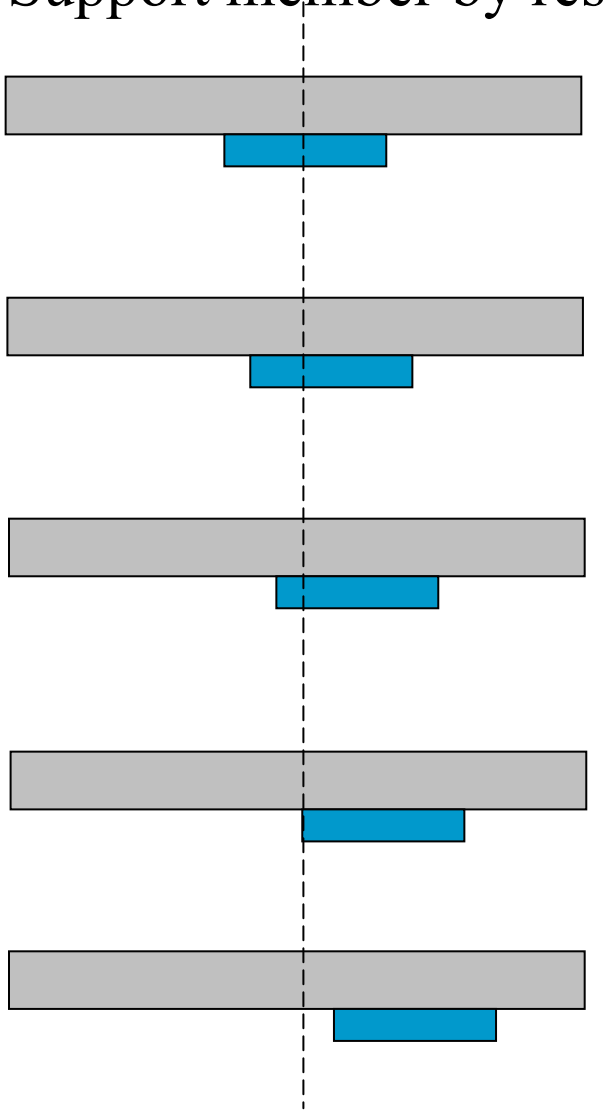
Does hand always exert a net force which acts through the center of the area of contact?

Yes Gr

No Pi

Nonuniform Contact

Support member by resting it on a board located at various positions



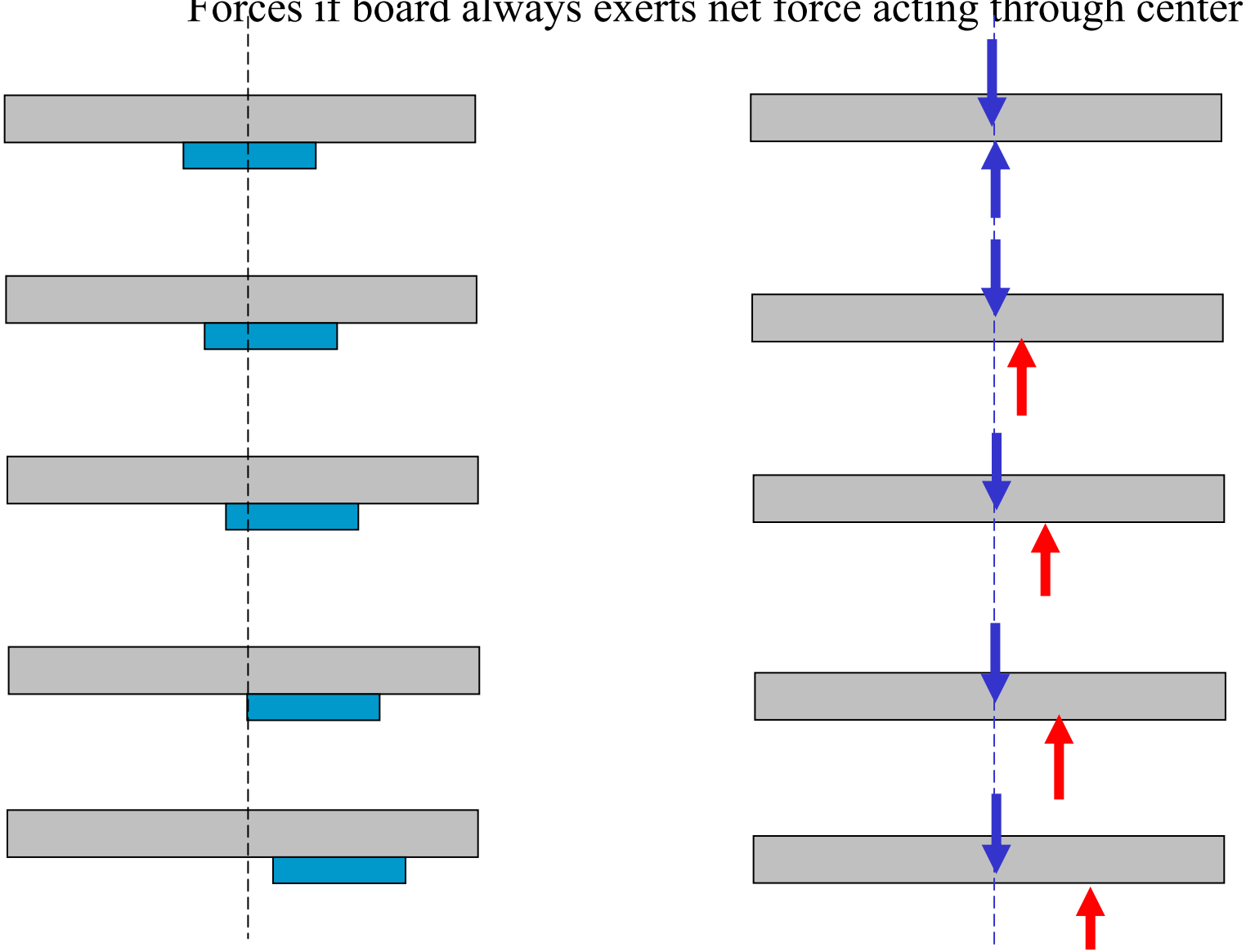
Does board always exert a net force which acts through the center of the area of contact?

Yes Gr

No Pi

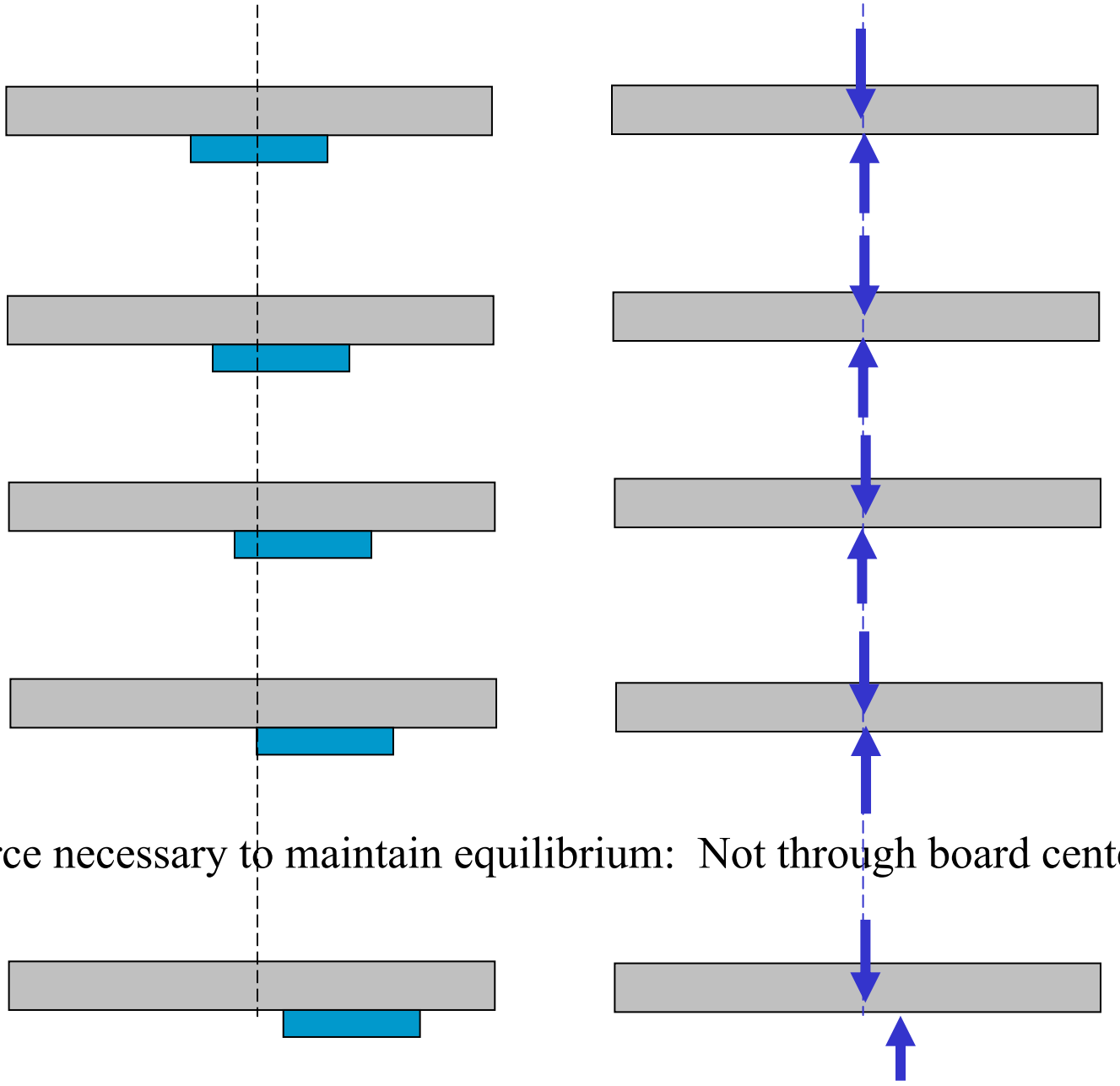
Nonuniform Contact

Forces if board always exerts net force acting through center:



Moments would not be in equilibrium!

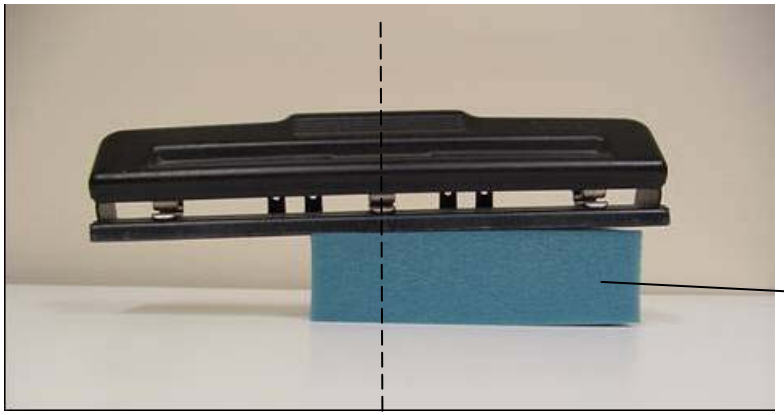
Nonuniform Contact



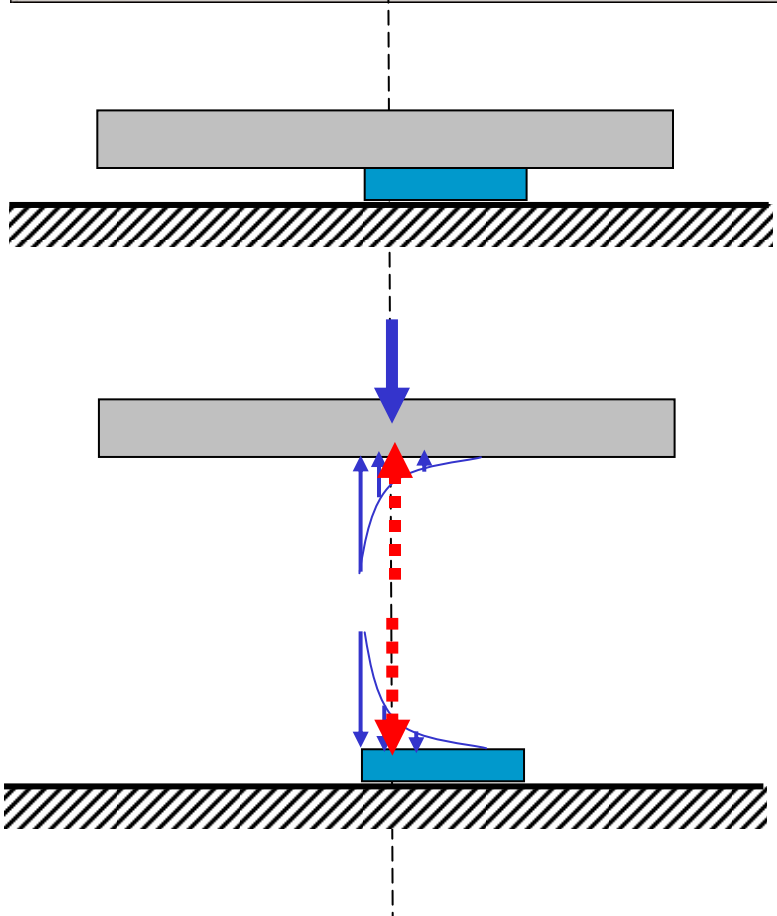
Force necessary to maintain equilibrium: Not through board center!

Cannot be balanced!

Nonuniform Contact

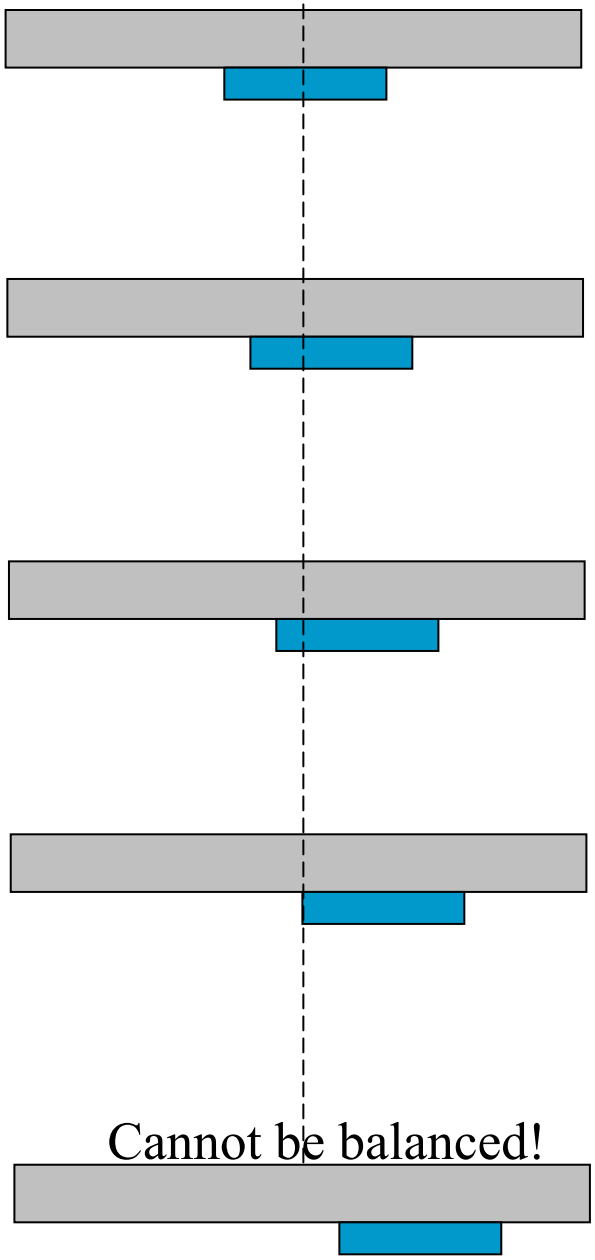


Object is placed off center on a foam block

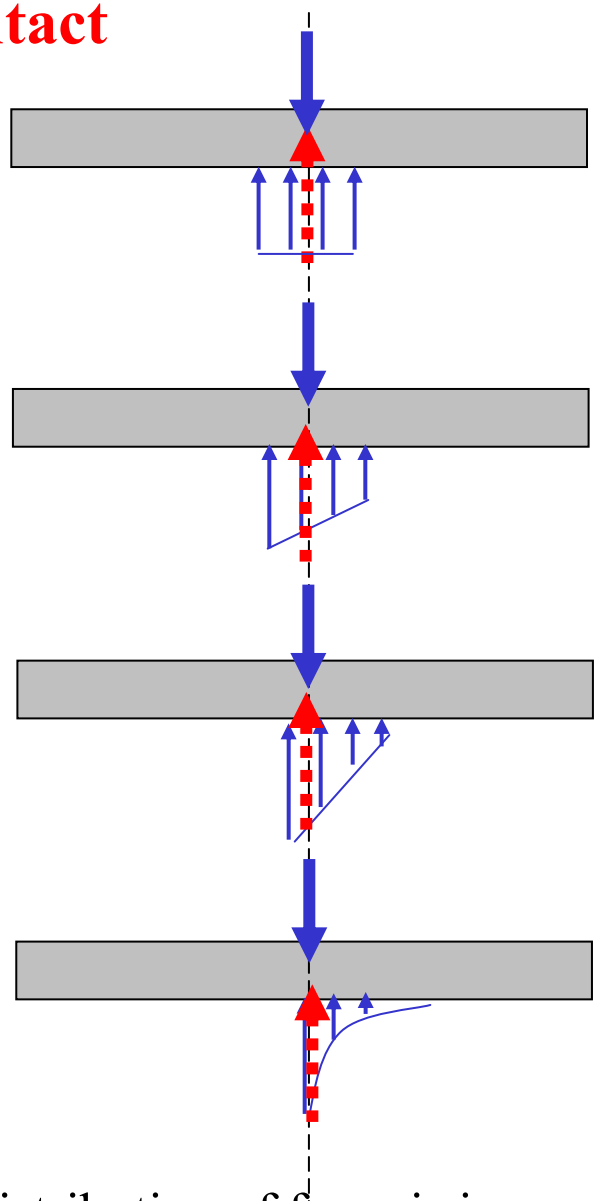


Deformation of the supporting foam seen as evidence that the distribution of contact force between the two bodies (puncher and foam block) is non-uniform

Nonuniform Contact



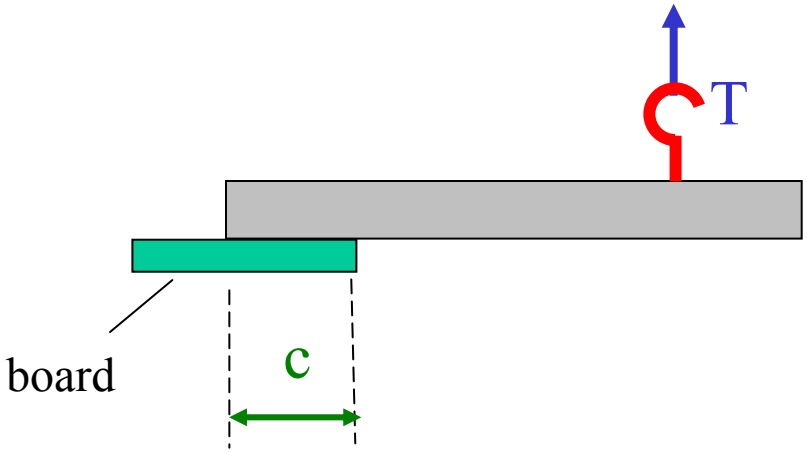
Cannot be balanced!



Distribution of force is increasingly non-uniform

Equilibrium with Distributed Contact Forces

The member's weight is supported by a cord attached to the right hook, and by a board under the left portion of the member.



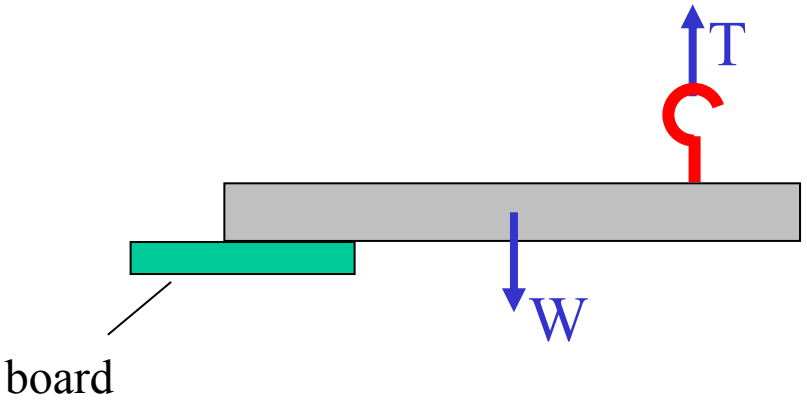
The support of the board is always statically equivalent to a single force F in the center of the area of contact, no matter the value of T.

True **Gr**

False **Pi**

Equilibrium with Distributed Contact Forces

The member's weight is supported by a cord attached to the right hook, and by a board under the left portion of the member.



Which of the following is true?

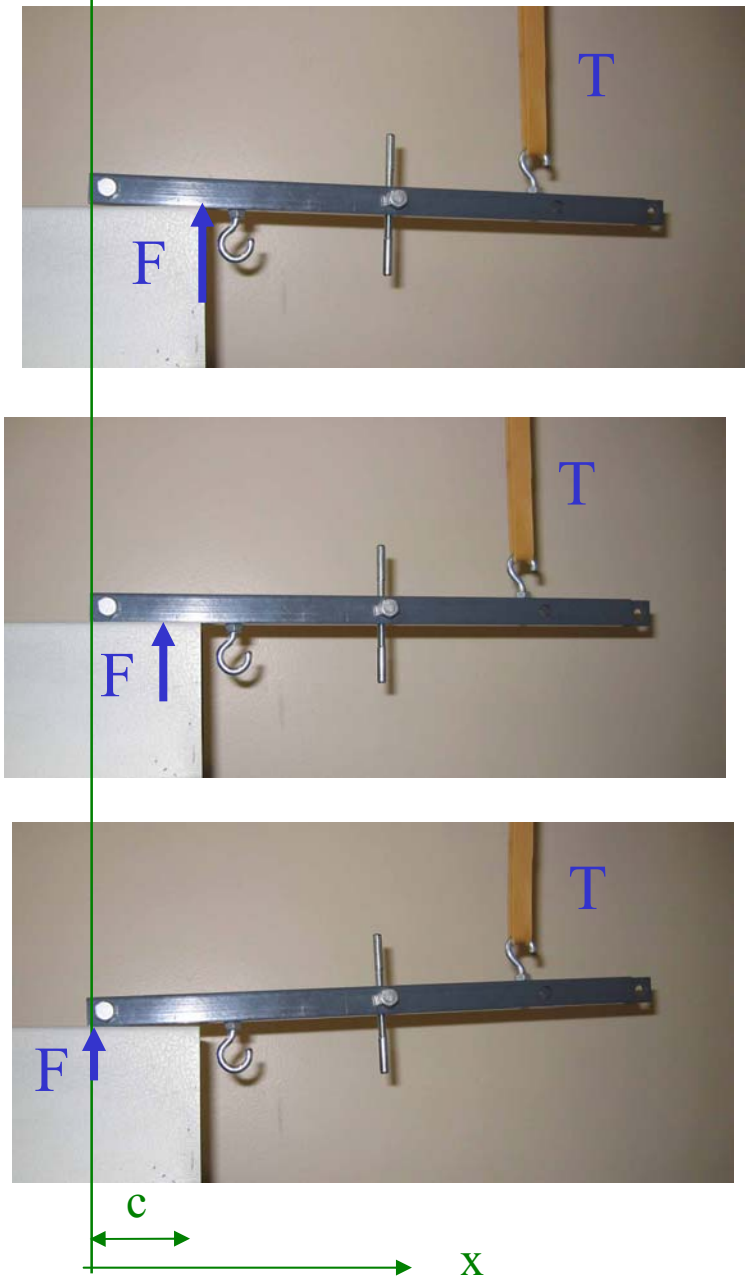
Wh There is only one tension T which will maintain equilibrium

Pi There is a lower limit and an upper limit to the tensions T that can maintain equilibrium

Bl There is a lower limit to the tensions T that can maintain equilibrium, but no upper limit

Ye There is an upper limit to the tensions T that can maintain equilibrium, but no lower limit

Equilibrium with Distributed Contact Forces



$x = c$

T_{min} , F_{max}

$0 < x < c$

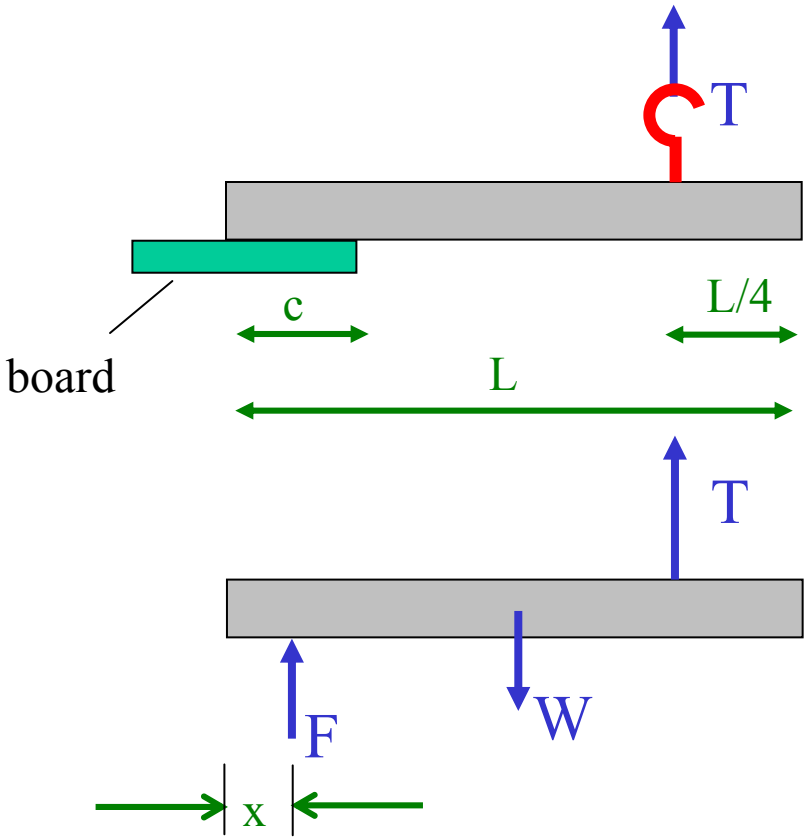
$T_{min} < T < T_{max}$

$x = 0$

T_{max} , F_{min}

Equilibrium with Distributed Contact Forces

The member's weight is supported by a cord attached to the right hook, and by a board under the left portion of the member.



$\Sigma F_y = 0$: F+T-W=0

$\Sigma M_c = 0$: F(L/2-x)=TL/4

F=W-T

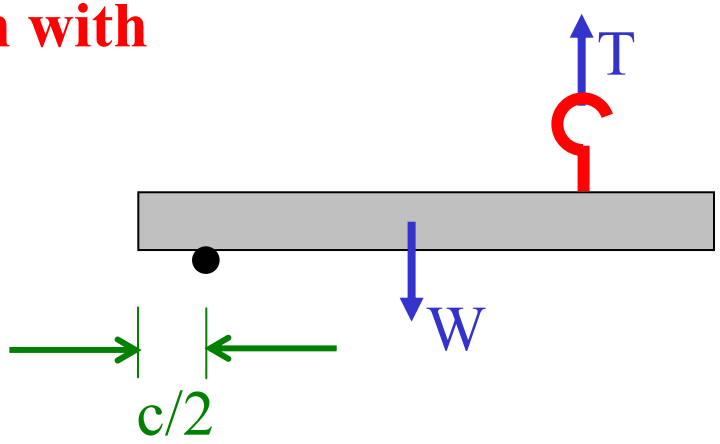
x=L(2W-3T) / 4(W-T) ; and $0 < x < c$

For x=0 T_{max}=2/3W F_{min} = W/3

For x=c T_{min}= W(2L-4c)/(3L-4c) F_{max} = WL/(3L-4c)

Nonuniform Contact – comparison with a concentrated force

Now the member is supported by a rod placed at the point midway along the region which was earlier supported by the board.



Consider the tension T to maintain equilibrium.
Which of the following is true?

Wh There is only one tension T which will maintain equilibrium

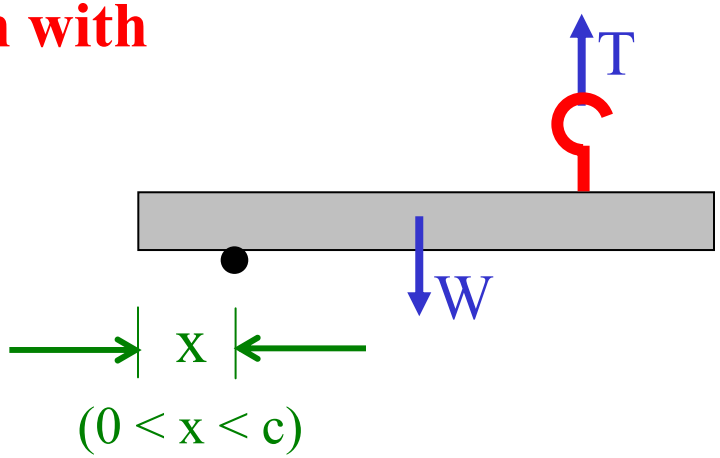
Pi There is a lower limit and an upper limit to the tensions T that can maintain equilibrium

Bl There is a lower limit to the tensions T that can maintain equilibrium, but no upper limit

Ye There is an upper limit to the tensions T that can maintain equilibrium, but no lower limit

Nonuniform Contact – comparison with a concentrated force

Now the member is supported by a rod which can be placed anywhere along the region which was earlier supported by the board.



Consider the tension T to maintain equilibrium. Which of the follow is true?

Wh There is only one tension T which will maintain equilibrium

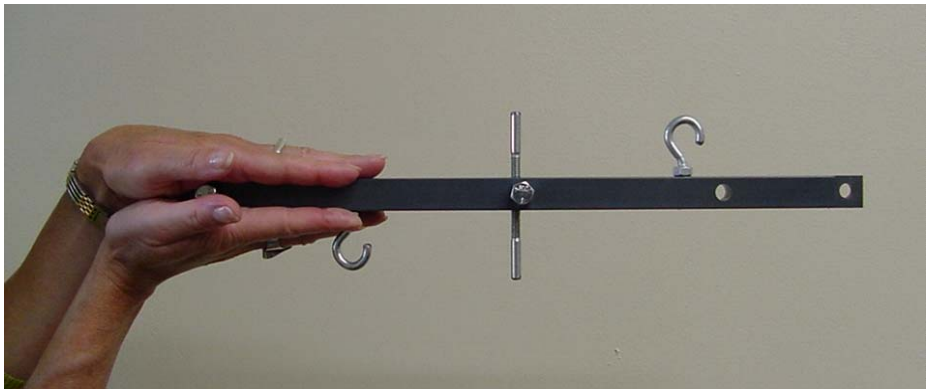
Pi There is a lower limit and an upper limit to the tensions T that can maintain equilibrium

Bl There is a lower limit to the tensions T that can maintain equilibrium, but no upper limit

Ye There is an upper limit to the tensions T that can maintain equilibrium, but no lower limit

Fixed support (no friction)

Consider supporting the member in horizontal position with two hands at the end as shown



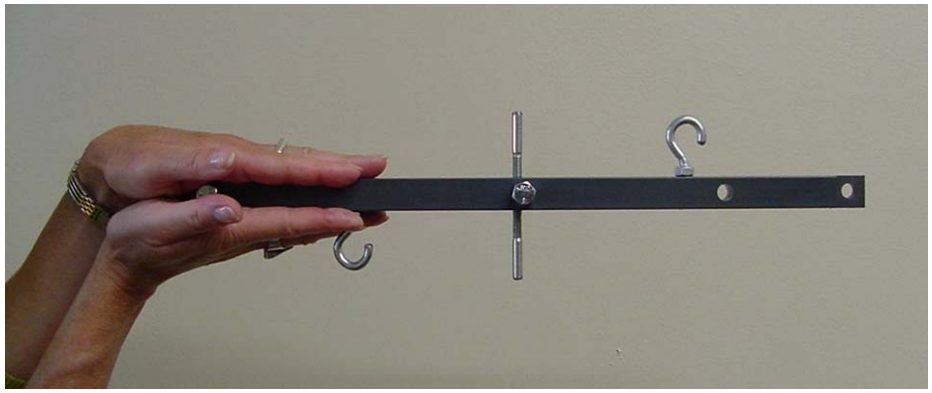
The two hands together exert only a net force N acting somewhere along the contact length

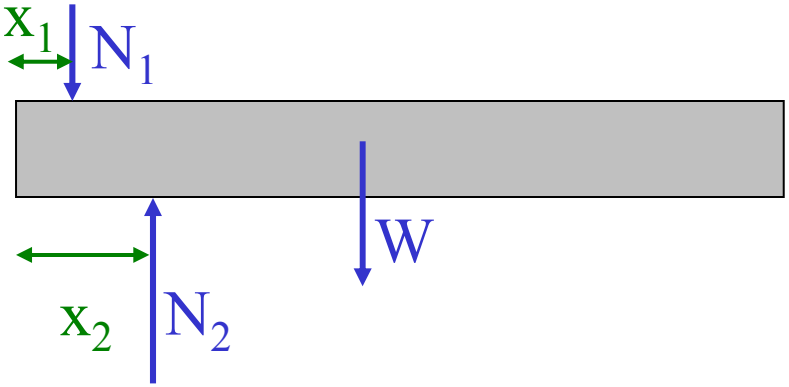
True Gr

False Pi

Fixed support (no friction)

Consider supporting the member in horizontal position with two hands at the end as shown





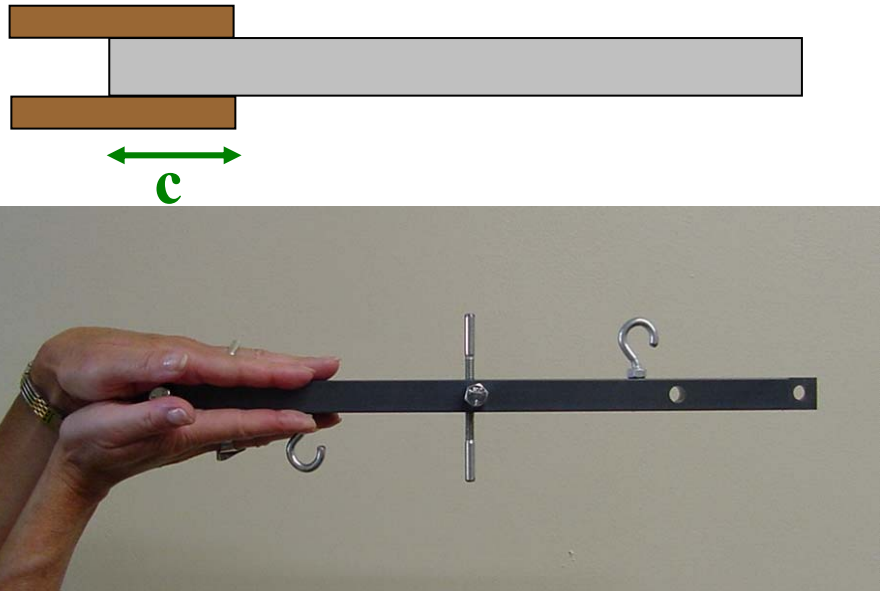
$0 < x_1 < c$

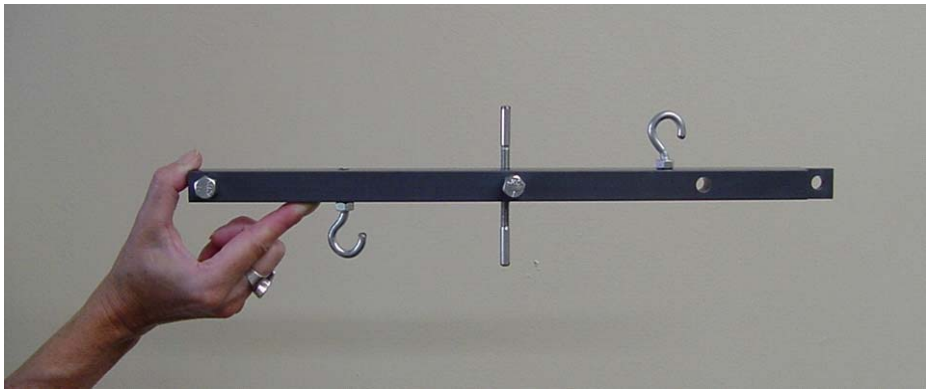
$0 < x_2 < c$

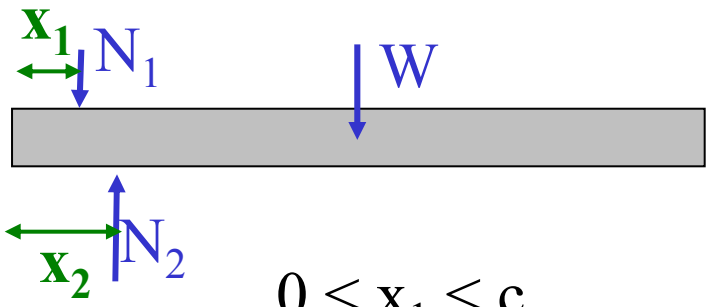
- Each hand exerts a net force somewhere along the area of contact.
- The positions x_1 and x_2 and magnitudes of the forces N_1 and N_2 depend on the distribution of contact force between the hand and member

Fixed support (no friction)

Compare two ways of supporting the member in horizontal position:

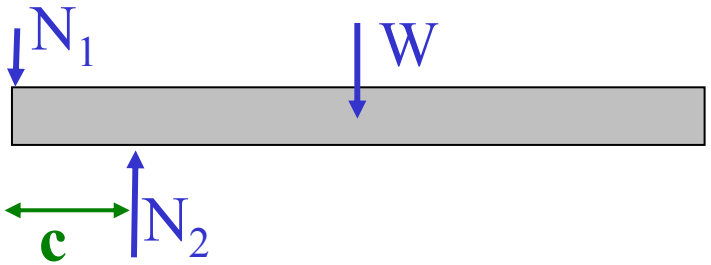






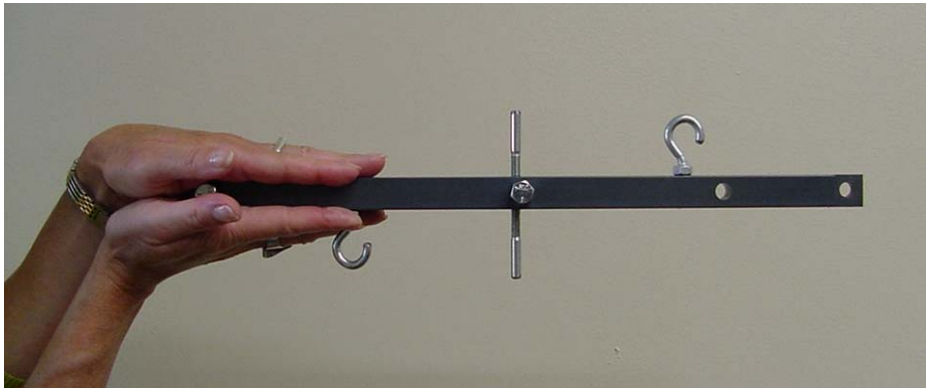
$0 < x_1 < c$

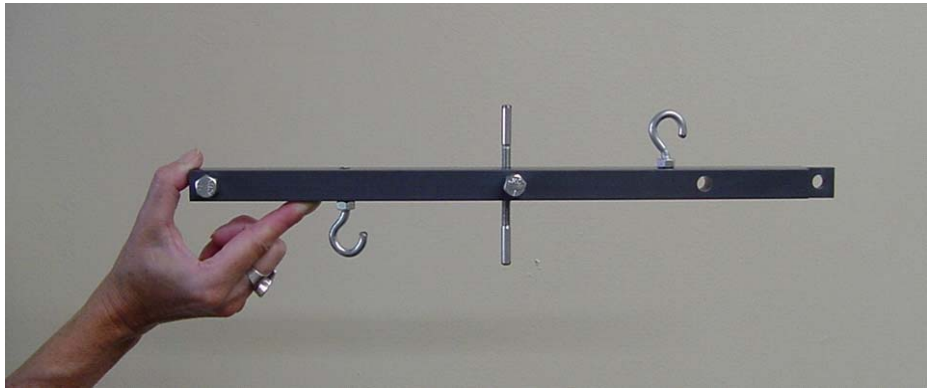
$0 < x_2 < c$



Fixed support (no friction)

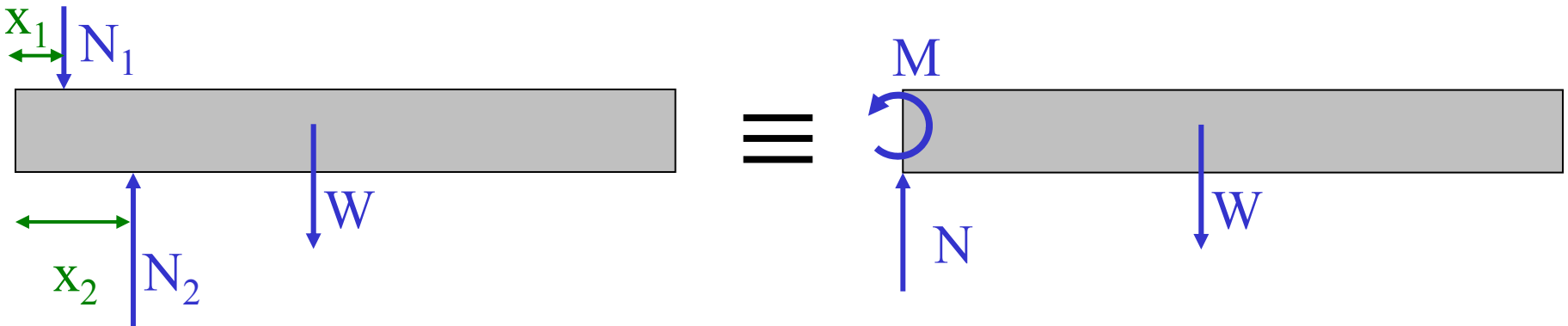
Compare two ways of supporting the member in horizontal position





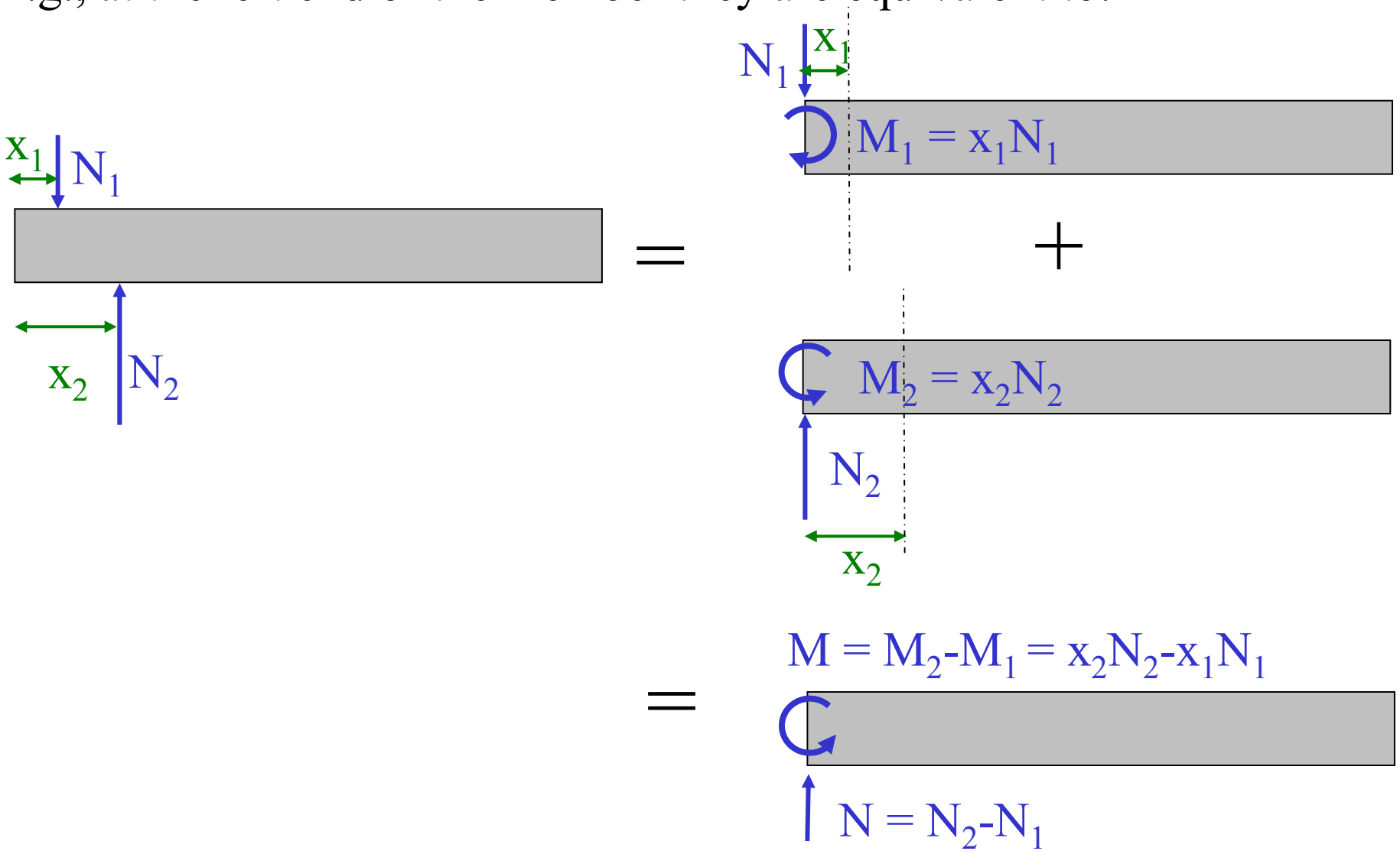
In both cases the combination of forces N_1, N_2 must be equivalent to:

- a force to balance weight
- a couple to balance the moment created by weight

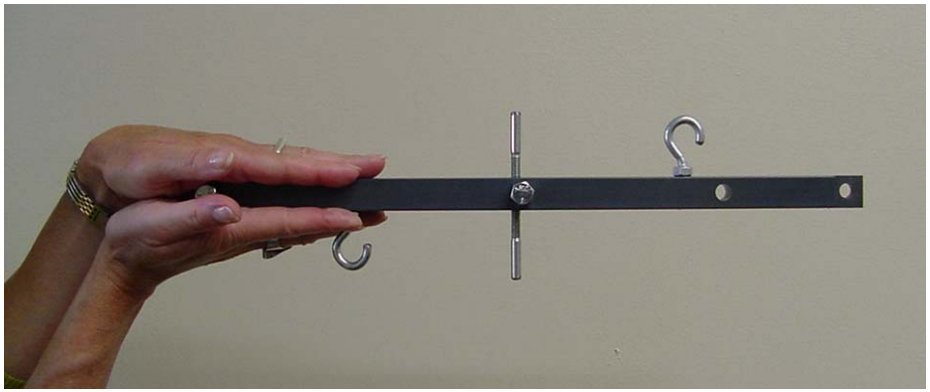


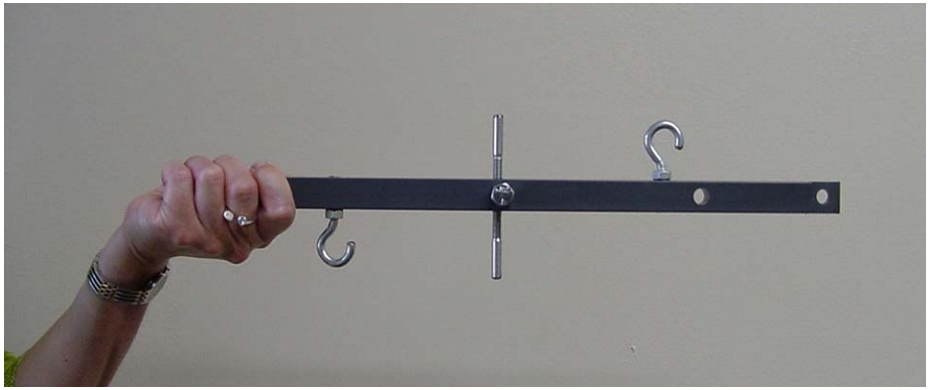
Fixed support (no friction)

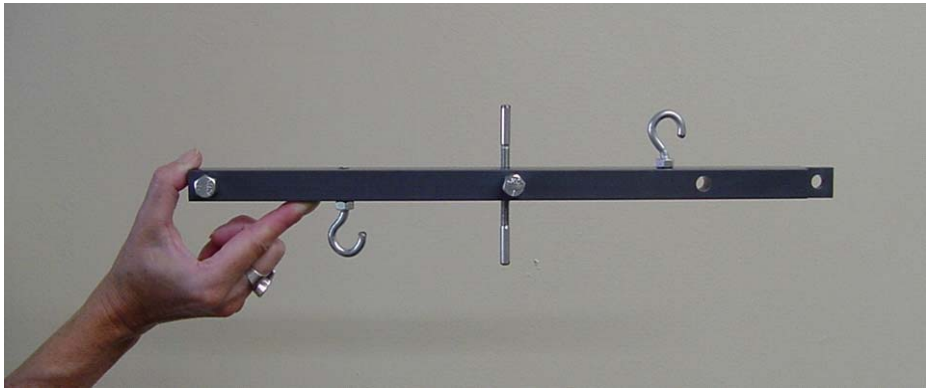
Forces N_1 and N_2 are statically equivalent to a force and a couple.
E.g., at the left end of the member they are equivalent to:

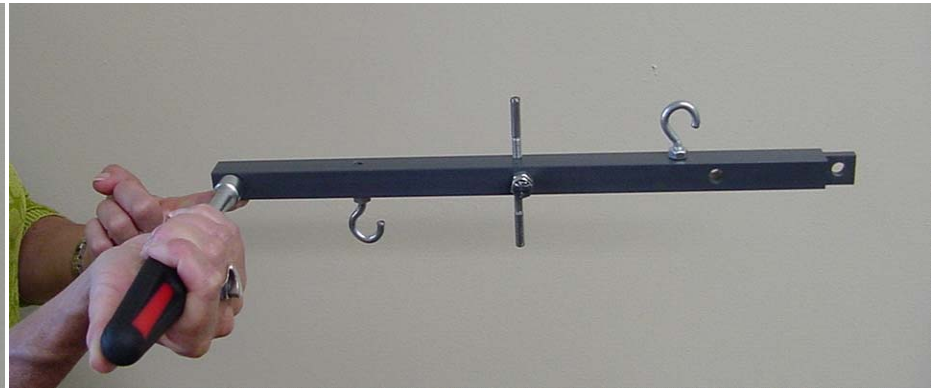


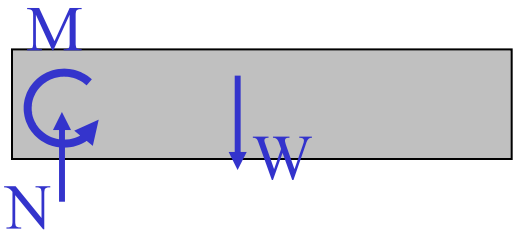
Fixed support (no friction)







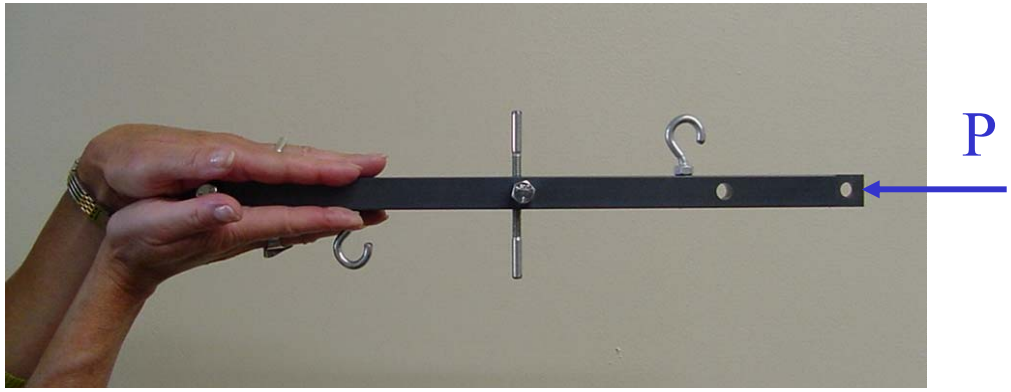




In all cases the “fixed support” provides a net force and a couple

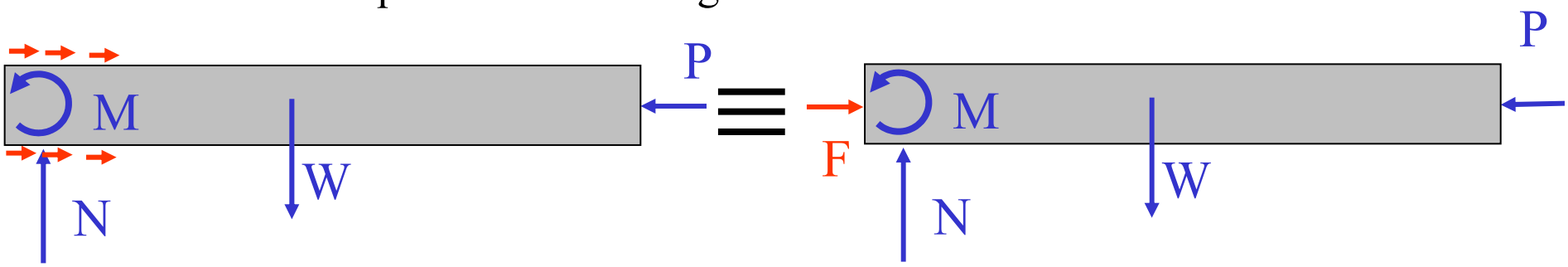
Fixed support (with friction)

Is it possible for this fixed support to resist a horizontal force applied to the member at the opposite end?



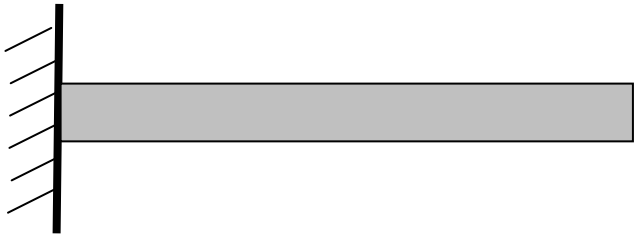
The two hands together exert:

- a distribution of frictional forces, acting along the contact length, to balance the horizontal force P
- a force and a couple to balance weight



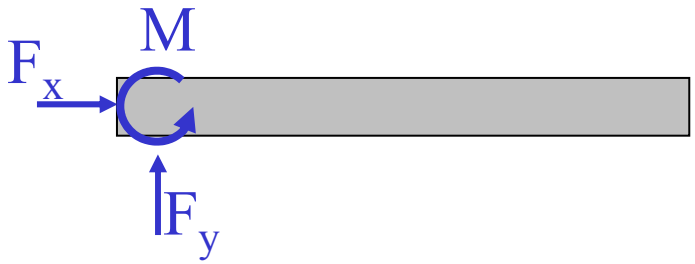
Fixed support in 2D - summary

Fixed or cantilevered support is represented graphically with :



If necessary to balancing the applied loads, the fixed support can provide:

- a net horizontal force
- a net vertical force
- a couple



The magnitude and direction of the forces and couple provided by the support depend on the loads applied to the member.

- F_x could act to the left, to the right, or be zero
- F_y could act up, or down, or be zero
- M could act clockwise, or counterclockwise, or be zero