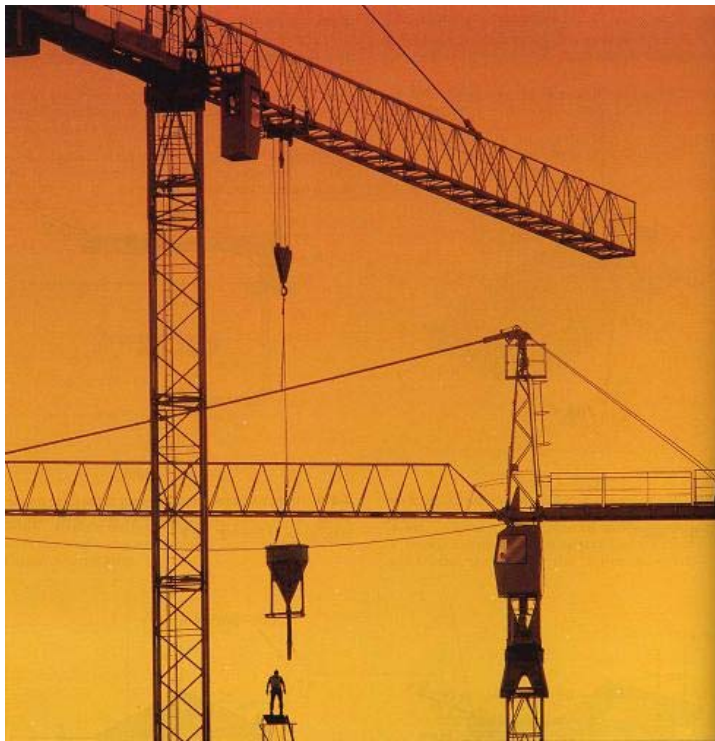


EQUILIBRIUM OF A RIGID BODY & FREE-BODY DIAGRAMS

Today's Objectives:

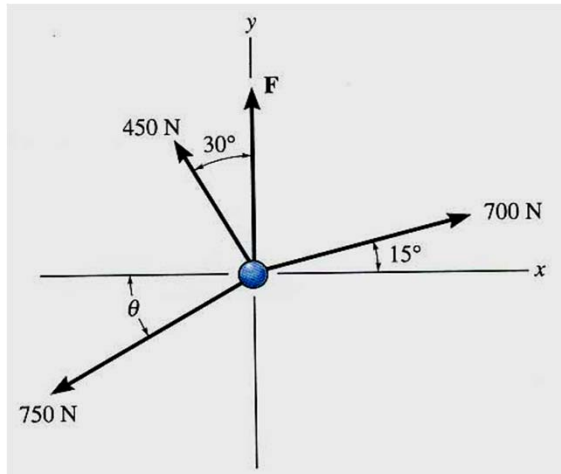
Students will be able to:

- a) Identify support reactions, and,
- b) Draw a free-body diagram.



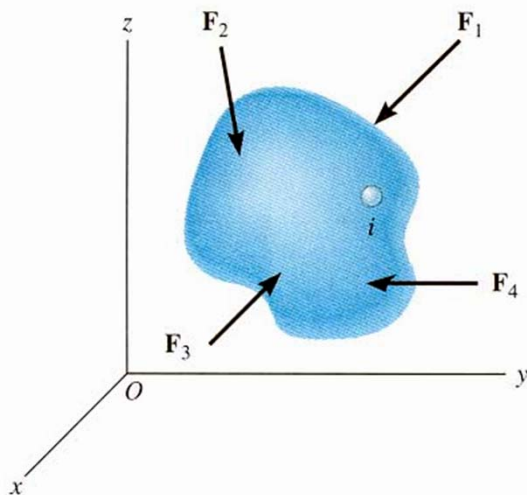
CONDITIONS FOR RIGID-BODY EQUILIBRIUM

(Section 5.1)



Forces on a particle

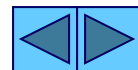
In contrast to the forces on a particle, the forces on a rigid-body are not usually concurrent and may cause rotation of the body (due to the moments created by the forces).



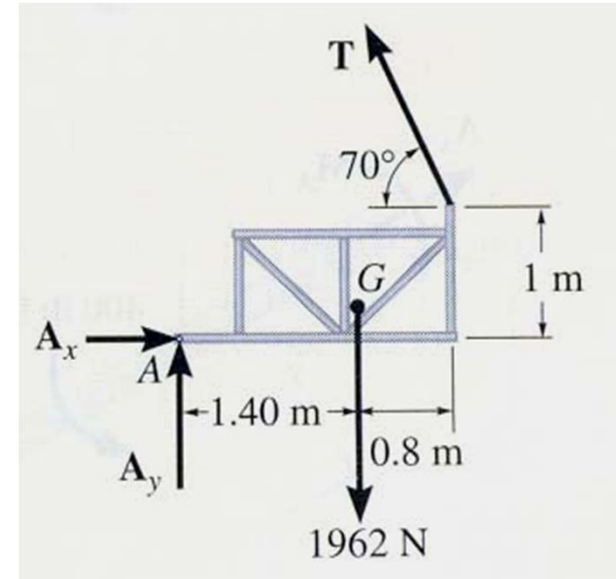
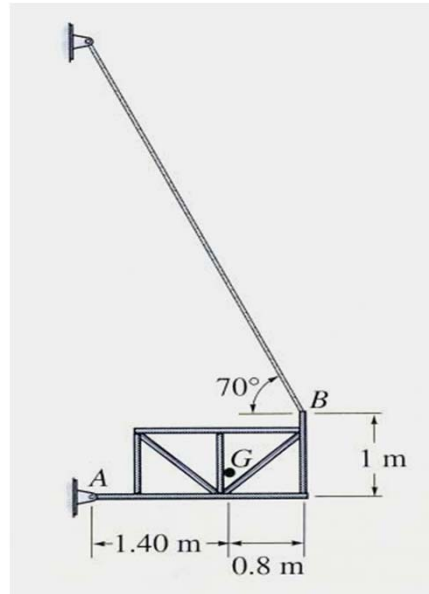
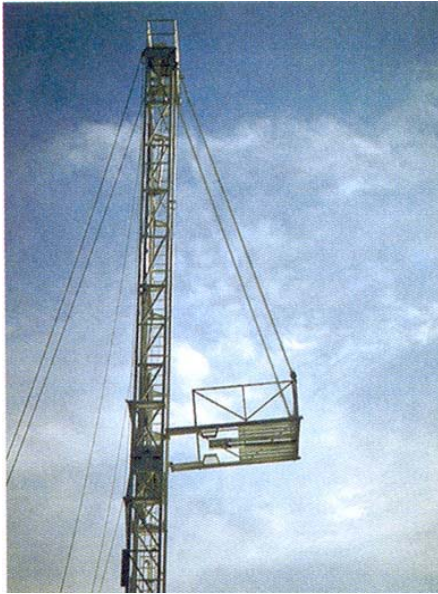
Forces on a rigid body

For a rigid body to be in equilibrium, the net force as well as the net moment about any arbitrary point O must be equal to zero.

$$\sum \mathbf{F} = 0 \text{ and } \sum \mathbf{M}_O = 0$$



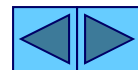
THE PROCESS OF SOLVING RIGID BODY EQUILIBRIUM PROBLEMS



For analyzing an actual physical system, first we need to create an idealized model. The object separate from its surroundings.

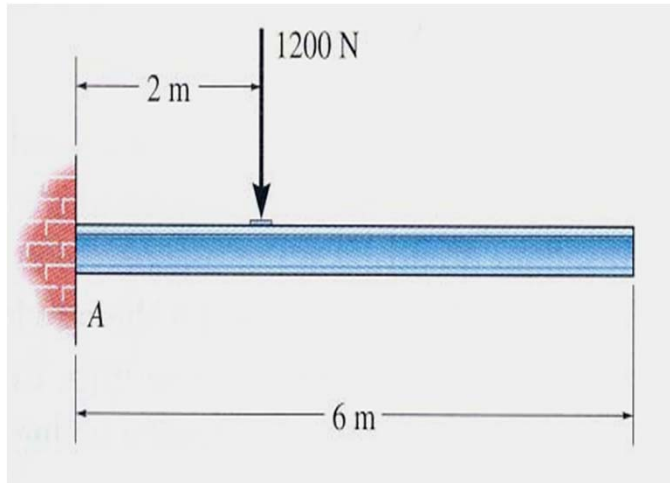
Then we need to draw a free-body diagram showing all the external (active and reactive) forces. (Hard part is support reactions)

Finally, we need to apply the equations of equilibrium to solve for any unknowns.

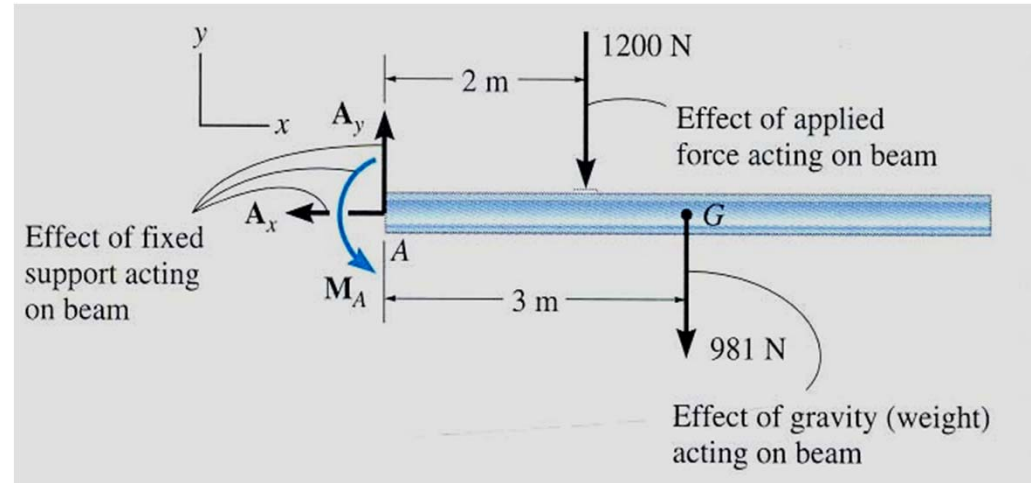


FREE-BODY DIAGRAMS

(Section 5.2)

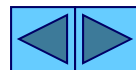


Idealized model



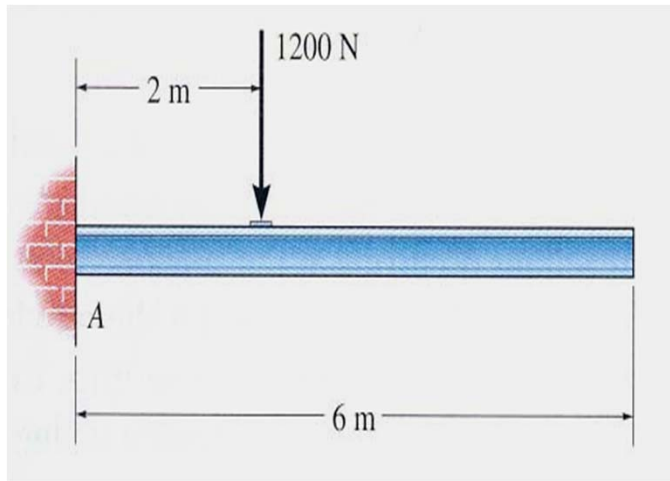
Free-body diagram

1. Draw an outlined shape. Imagine the body to be isolated or cut “free” from its constraints and draw its outlined shape.
2. Show all the external forces and couple moments. These typically include: a) applied loads, b) the weight of the body, and c) support reactions (can be difficult).

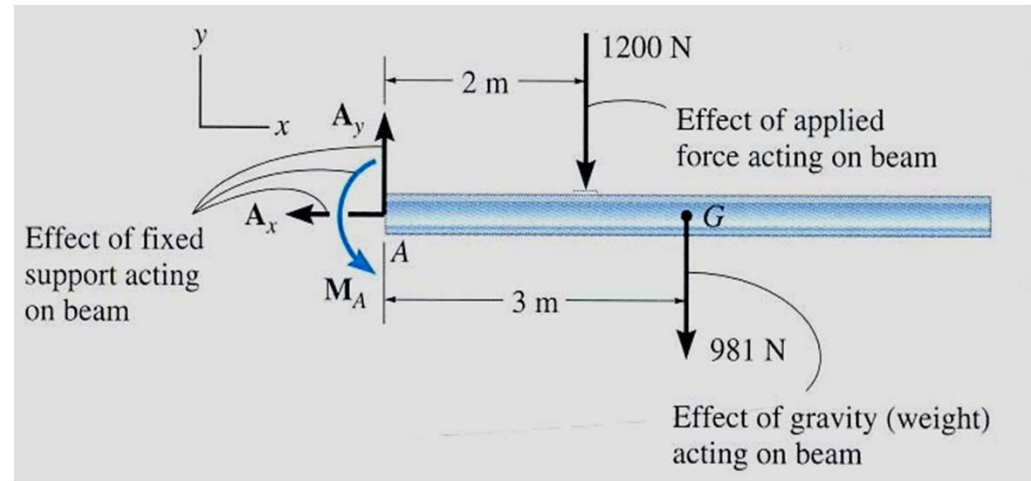


FREE-BODY DIAGRAMS

(continued)



Idealized model

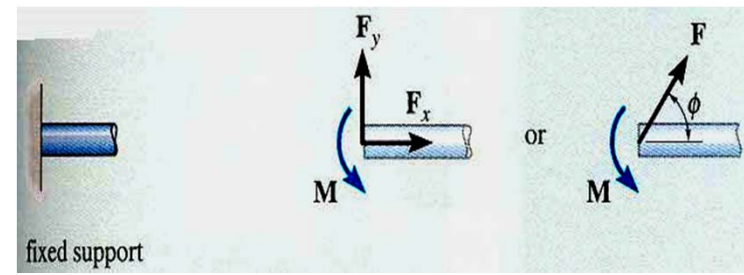
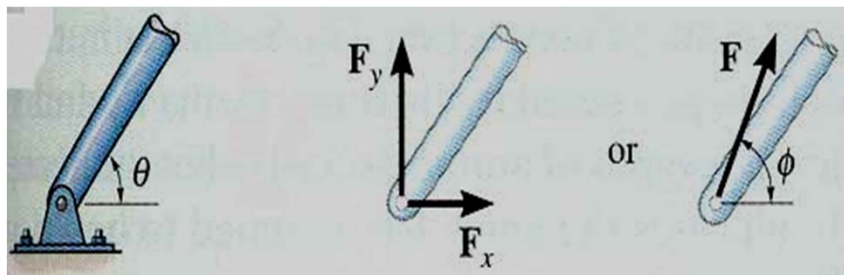
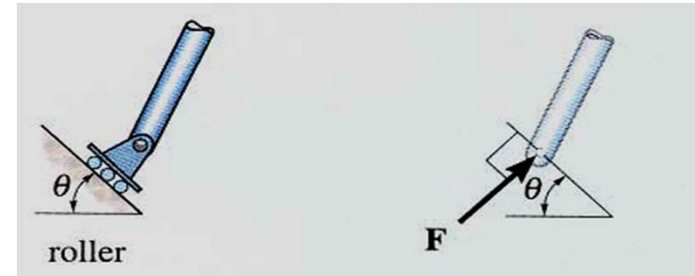
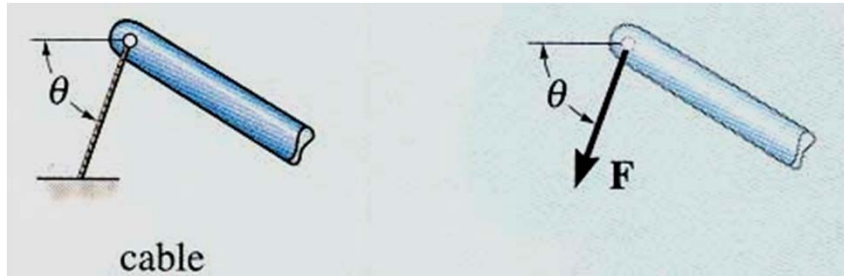


Free-body diagram

3. Label loads and dimensions: All known forces and couple moments should be labeled with their magnitudes and directions. For the unknown forces and couple moments, use letters like A_x , A_y , M_A , etc.. Indicate any necessary dimensions.

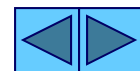


SUPPORT REACTIONS IN 2-D

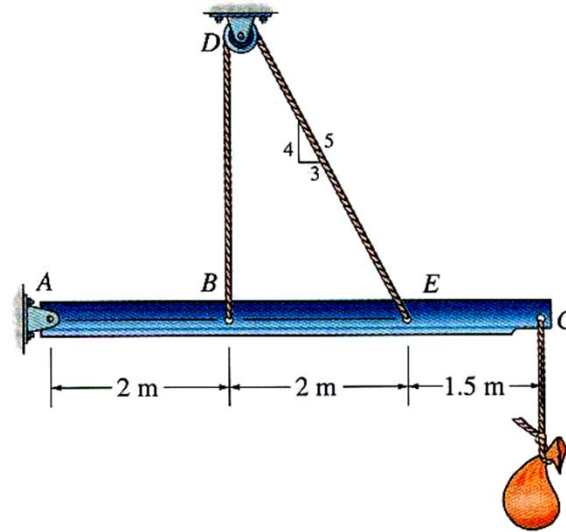


A few examples are shown above. Other support reactions are given in your textbook (in [Table 5-1](#)).

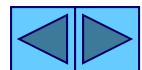
- If a support prevents translation of a body in a direction b , then a force F_b is developed on the body in the opposite direction.
- If rotation is prevented in direction b , a couple moment M_b is exerted on the body. (Review 5-1)



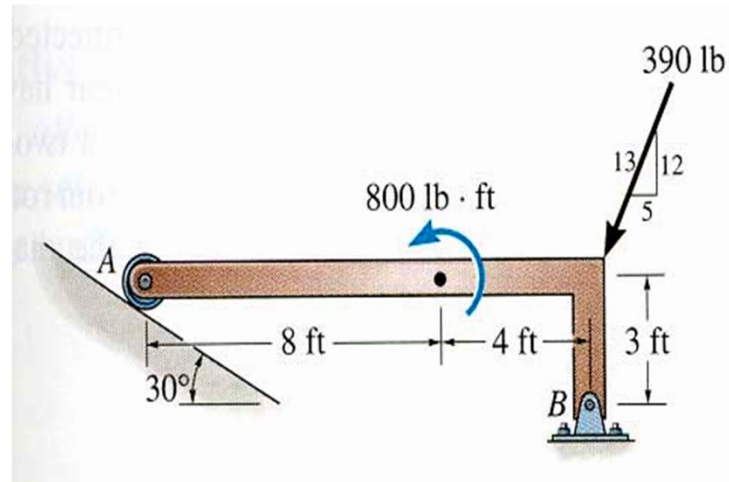
CONCEPT QUIZ



1. The beam and the cable (with a frictionless pulley at D) support an 80 kg load at C. In a FBD of only the beam, there are how many unknowns?
- 1) 2 forces and 1 couple moment
 - 2) 3 forces and 1 couple moment
 - 3) 3 forces
 - 4) 4 forces



CONCEPT QUIZ



2. If the directions of the force and the couple moments are reversed, then what will happen to the beam?
- A) The beam will lift from A.
 - B) The beam will lift at B.
 - C) The beam will be restrained.
 - D) The beam will break.



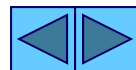
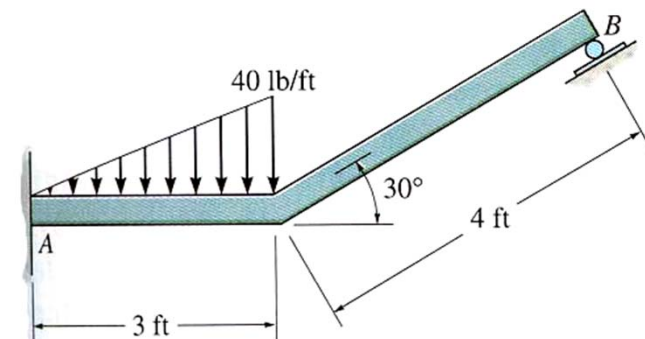
ATTENTION QUIZ

1. Internal forces are not shown on a free-body diagram because the internal forces are _____. (Choose the most appropriate answer.)

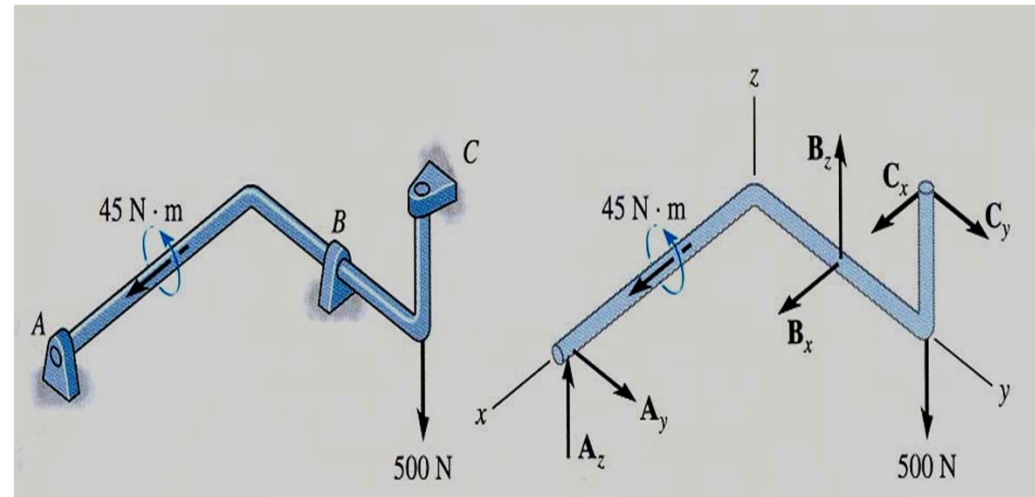
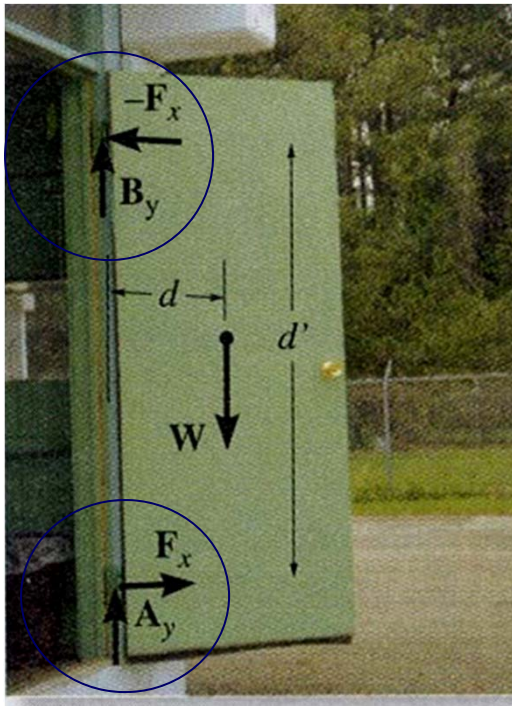
- A) equal to zero B) equal and opposite and they do not affect the calculations
C) negligibly small D) not important

2. How many unknown support reactions are there in this problem?

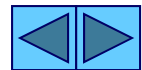
- 1) 2 forces and 2 couple moments
2) 1 force and 2 couple moments
3) 3 forces
4) 3 forces and 1 couple moment



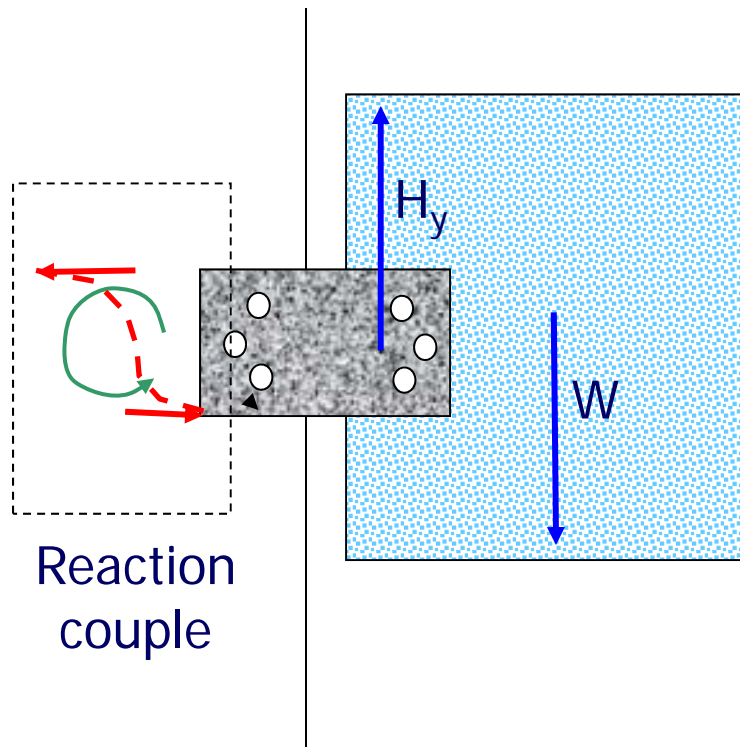
IMPORTANT NOTE



A single bearing or hinge can prevent rotation by providing a resistive couple moment. However, it is usually preferred to use two or more properly aligned bearings or hinges. Thus, in these cases, only force reactions are generated and there are no moment reactions created.



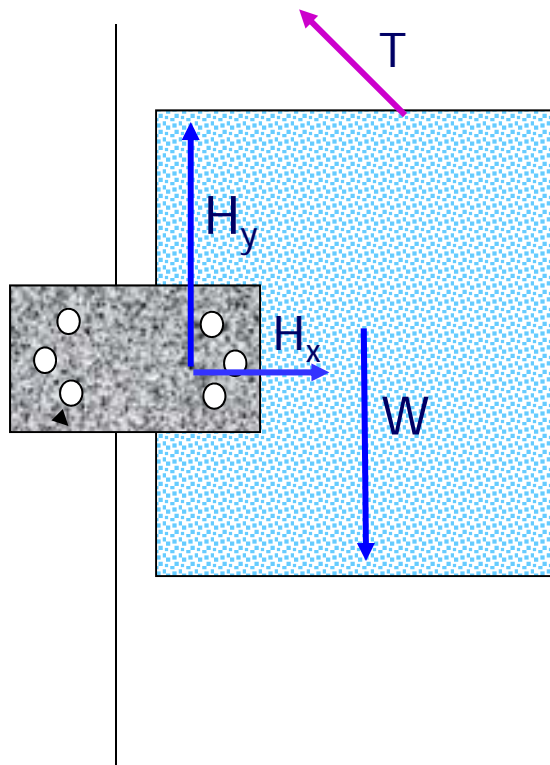
Reaction Couple Moment



To support weight of sign, hinge exerts upward force.

Weight twists hinge. So wall exerts reaction force distribution. The net force is zero but there is a non-zero couple moment.

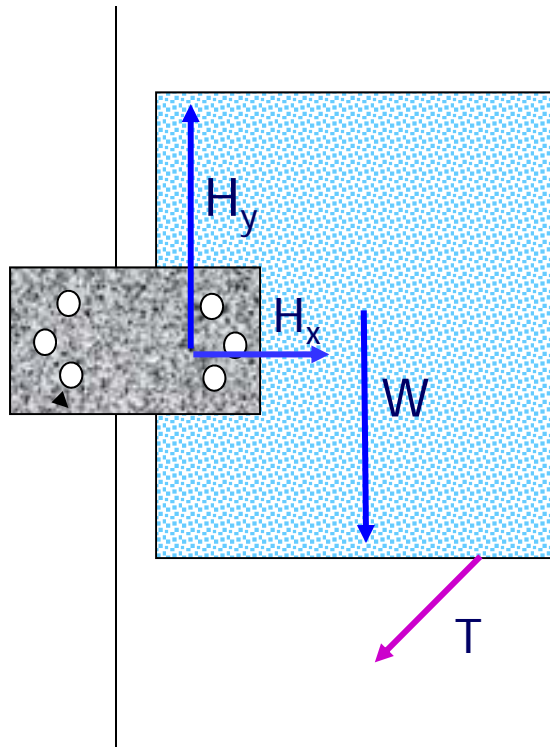
Properly Aligned Supports



A properly aligned support, prevents the twisting of the hinge.

The reaction couple of the hinge is negligible.

Improperly Aligned Supports



An improperly aligned support does nothing to prevent the twisting of the hinge or makes the twisting worse.

Are the Supports Properly Aligned?

- The problem says so.
- Are there more unknowns than equations?
- If we drop the reaction couple moments, do we have enough equations?