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.

In-Class Activities:

- Check Homework
- Reading Quiz
- Applications
- Support Reactions
- Free-Body Diagrams
- Example Problems
- Concept Quiz
- Group Problem Solving
- Attention Quiz

READING QUIZ

1. If a support prevents translation of a body, then the support exerts a ____________ on the body.

   A) Couple moment

   B) Force

   C) Both A and B.

   D) None of the above

2. Internal forces are __________ shown on the free body diagram of a whole body.

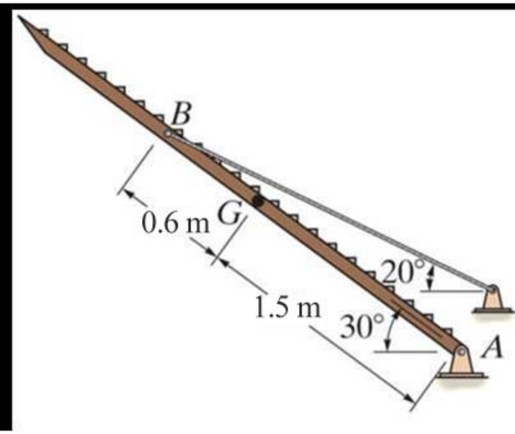
   A) Always

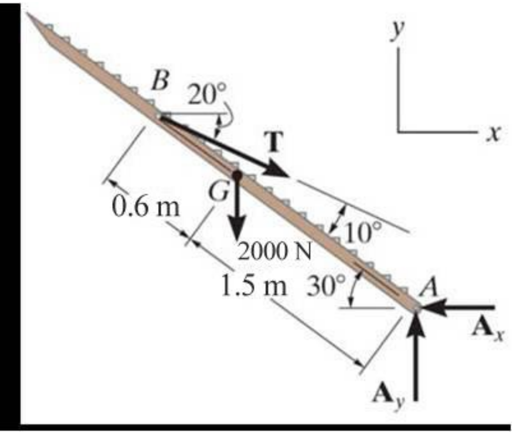
   B) Often

   C) Rarely

   D) Never

APPLICATIONS



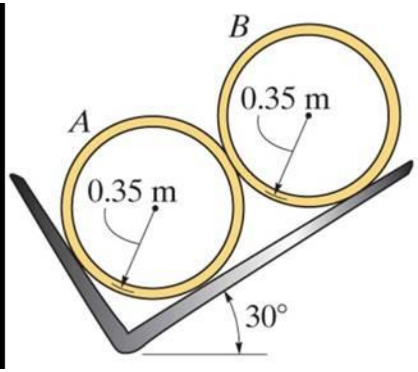


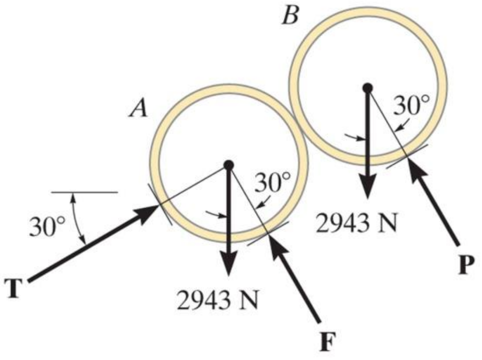
The truck ramps have a weight of 2000 N each.
Each ramp is pinned to the body of the truck and held in the position by a cable. How can we determine the cable tension and support reactions?

How are the idealized model and the free body diagram used to do this?

Which diagram above is the idealized model?

APPLICATIONS (continued)



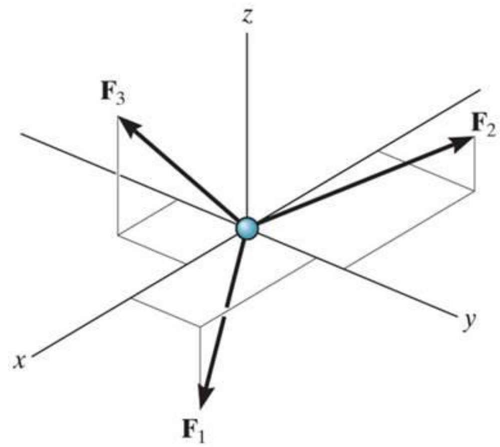


Two smooth pipes, each having a mass of 300 kg, are supported by the tines of the loader's fork attachment.

How can we determine all the reactive forces?

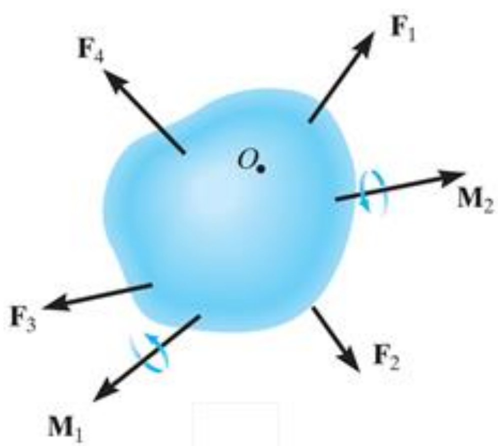
Again, how can we make use of an idealized model and a free body diagram to answer this question?

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 moments created by the forces).



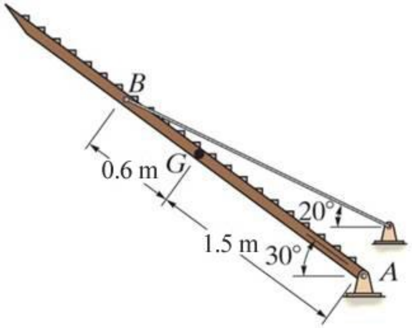
Forces on a rigid body

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.

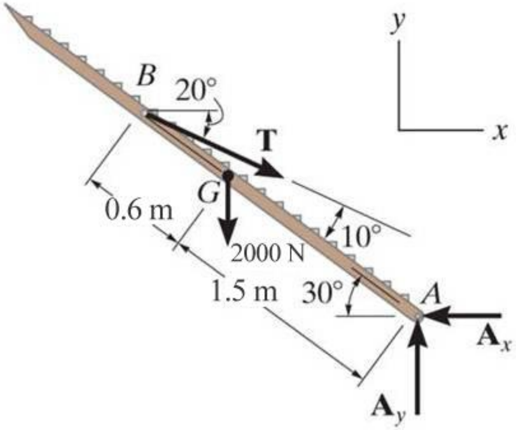
$\sum \boldsymbol{F} = 0$ (no translation)

and $\sum \boldsymbol{M_O} = 0$ (no rotation)

THE PROCESS OF SOLVING RIGID BODY EQUILIBRIUM PROBLEMS



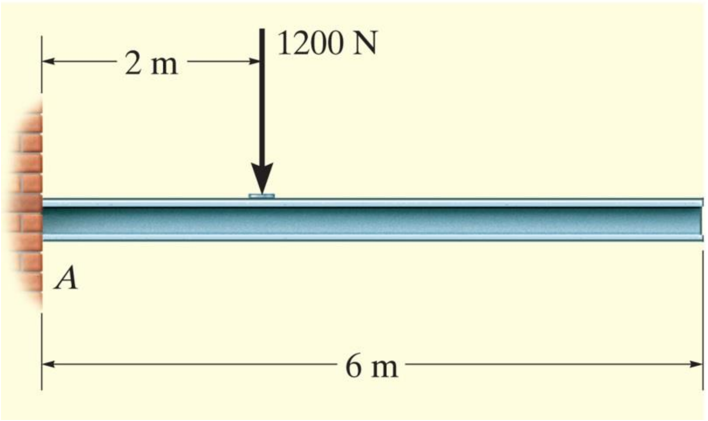
For analyzing an actual physical system, first we need to create an idealized model (above right).

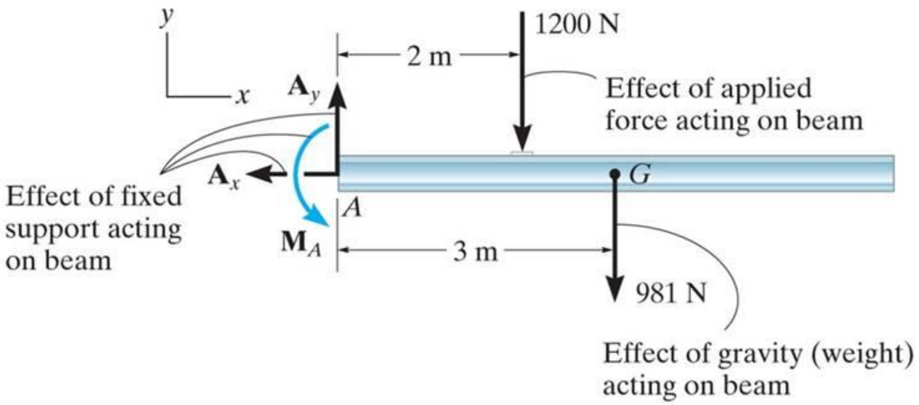


Then we need to draw a free-body diagram (FBD) showing all the external (active and reactive) forces.

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

FREE-BODY DIAGRAMS (Section 5.2)



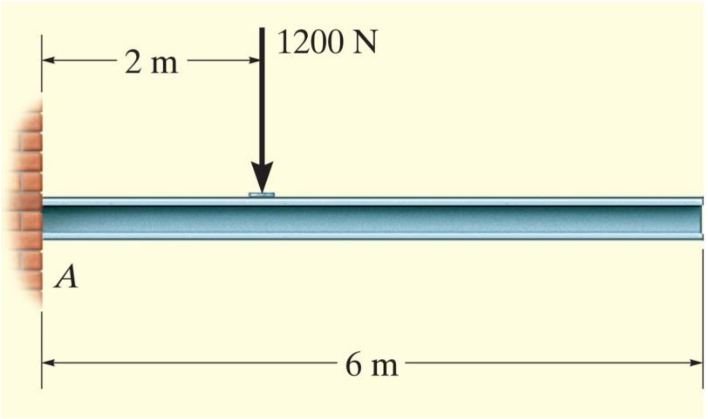


Idealized model

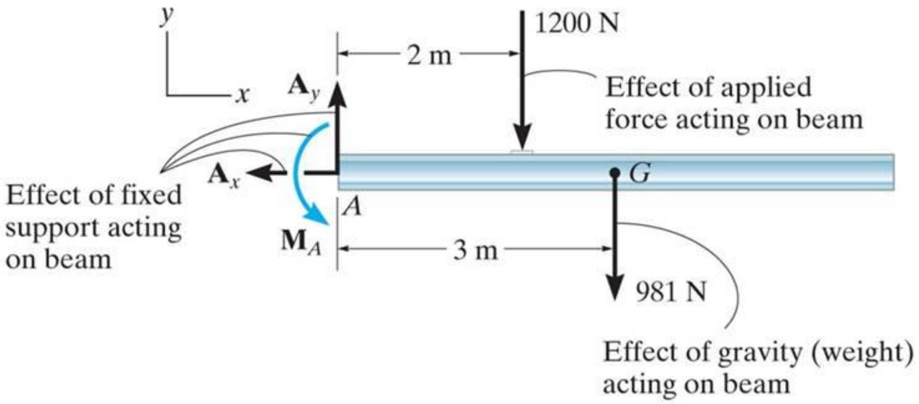
Free-body diagram (FBD)

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) support reactions, and, c) the weight of the body.

FREE-BODY DIAGRAMS (continued)



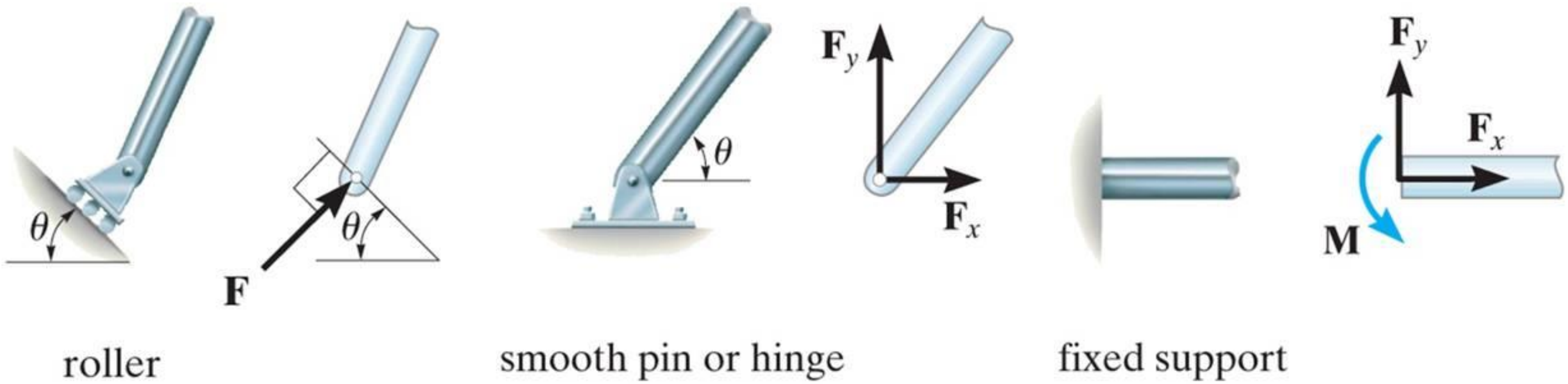
Idealized model



Free-body diagram

3. Label loads and dimensions on the FBD: 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. Indicate any necessary dimensions.

SUPPORT REACTIONS IN 2-D



A few example sets of diagrams s are shown above. Other support reactions are given in your textbook (Table 5-1).

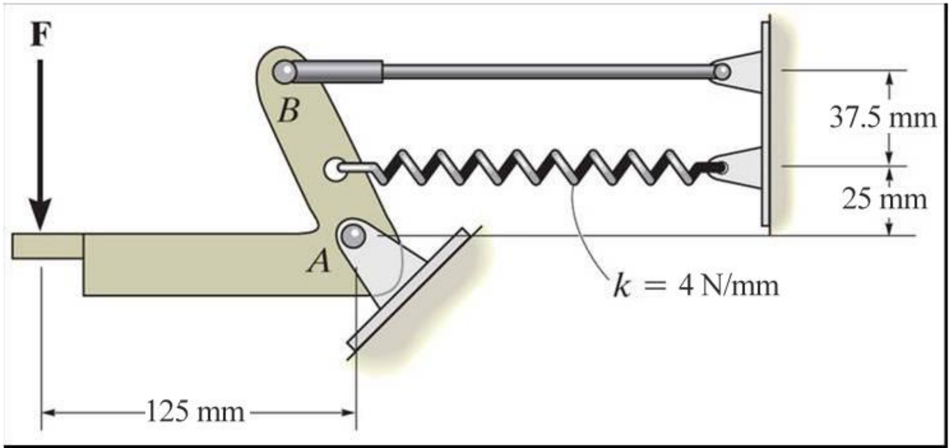
As a general rule, if a support prevents translation of a body in a given direction, then a force is developed on the body in the opposite direction.

Similarly, if rotation is prevented, a couple moment is exerted on the body in the opposite direction.

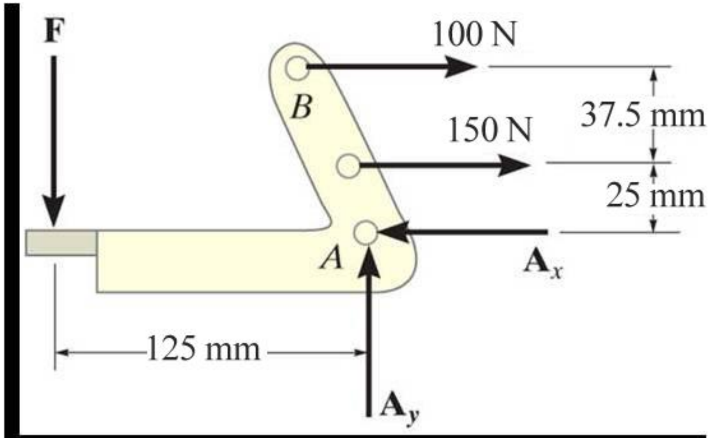
EXAMPLE I

Given: The operator applies a vertical force to the pedal so that the spring is stretched 37.5 mm and the force in the short link at *B is 100 N*.

Draw: An idealized model and free-body diagram of the foot pedal.



The idealized model



The free-body diagram

EXAMPLE II

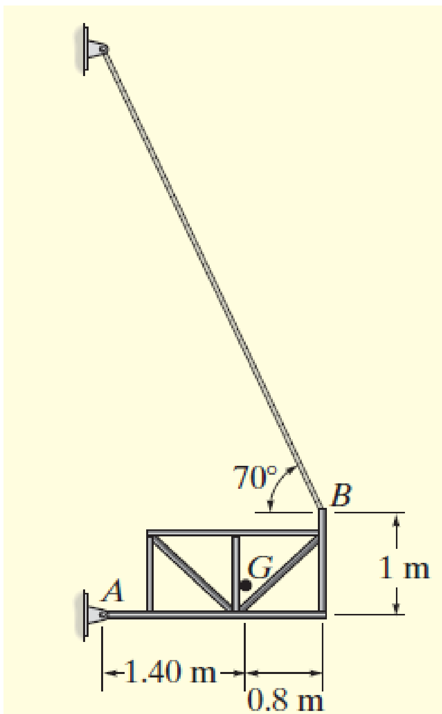
Given: The unloaded platform is suspended off the edge of the oil rig. The platform has a mass of 200 kg.

Draw: An idealized model and free-body diagram of the platform.

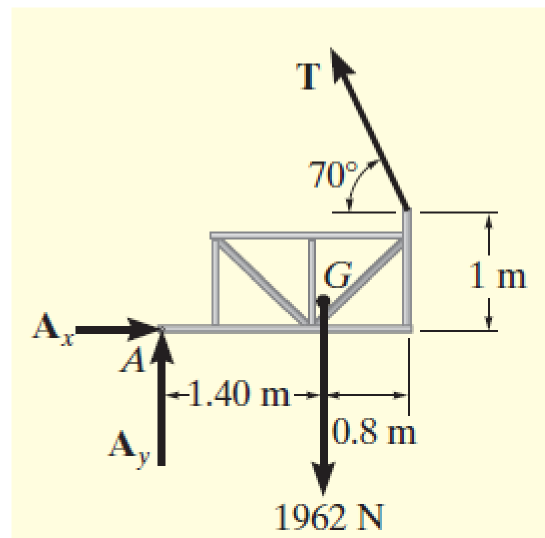
The idealized model of the platform is considered in two dimensions because the loading and the dimensions are all symmetrical about a vertical plane passing through its center.

EXAMPLE II (continued)

The connection at A is treated as a pin, and the cable supports the platform at B. Note the assumed directions of the forces! The point G is the center of gravity of the platform.



The idealized model



The free-body diagram

CONCEPT QUIZ

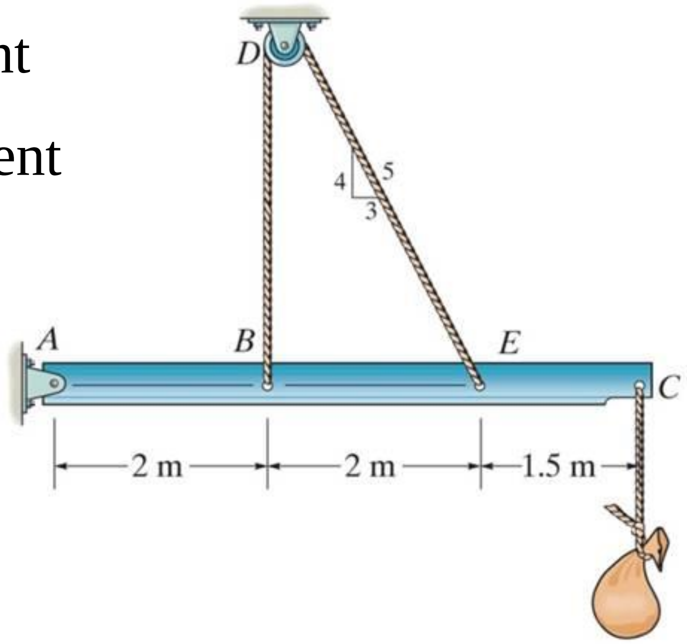
1. The beam and the cable (with a frictionless pulley at D) support an 80 kg load at C. In a FBD of only the beam, there are how many unknowns?

   A) Two forces and one couple moment

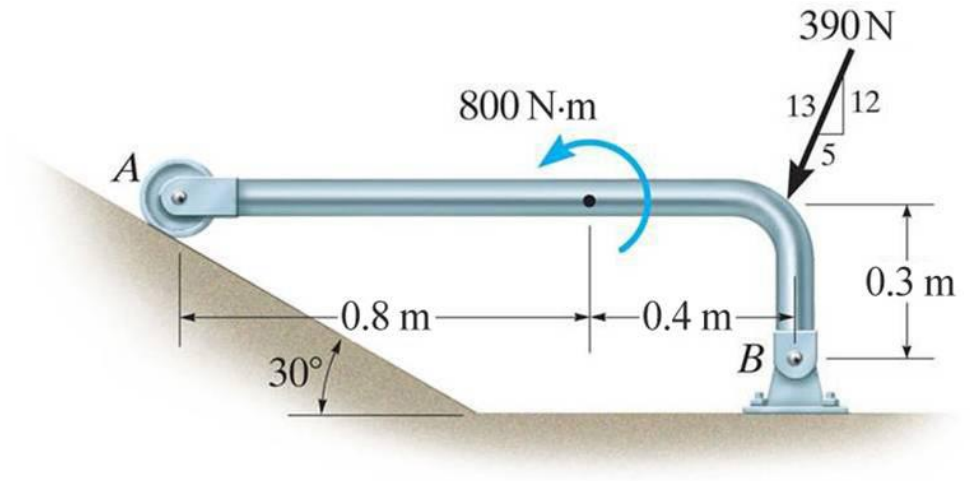
   B) Three forces and one couple moment

   C) Three forces

   D) Four forces



CONCEPT QUIZ (continued)

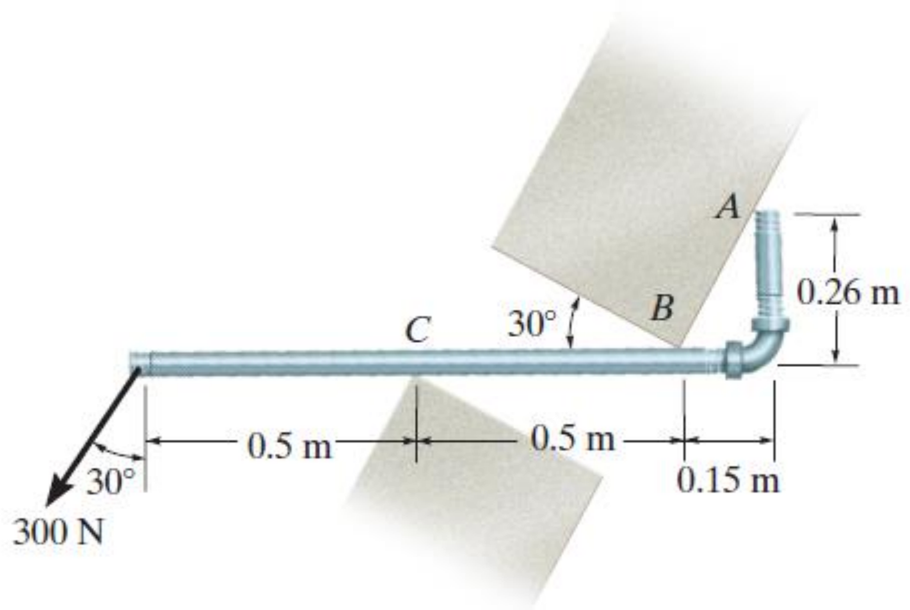


2. If the directions of the force and the couple moments are both reversed, what will happen to the beam?

   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.

GROUP PROBLEM SOLVING I

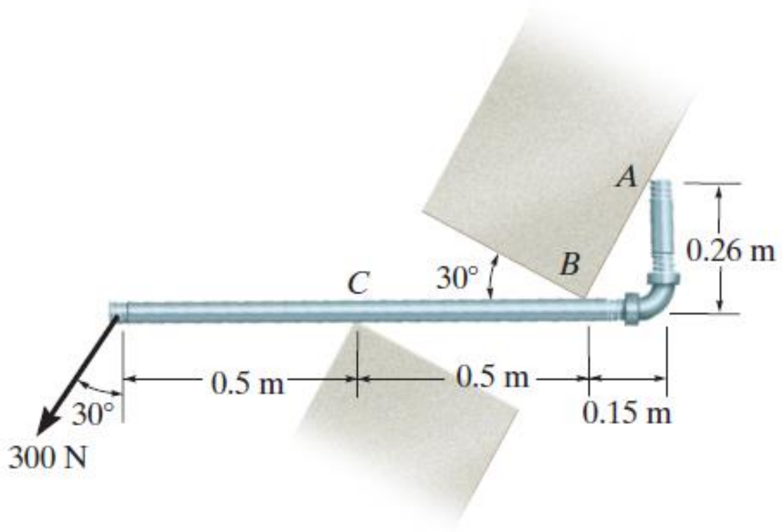
Given:



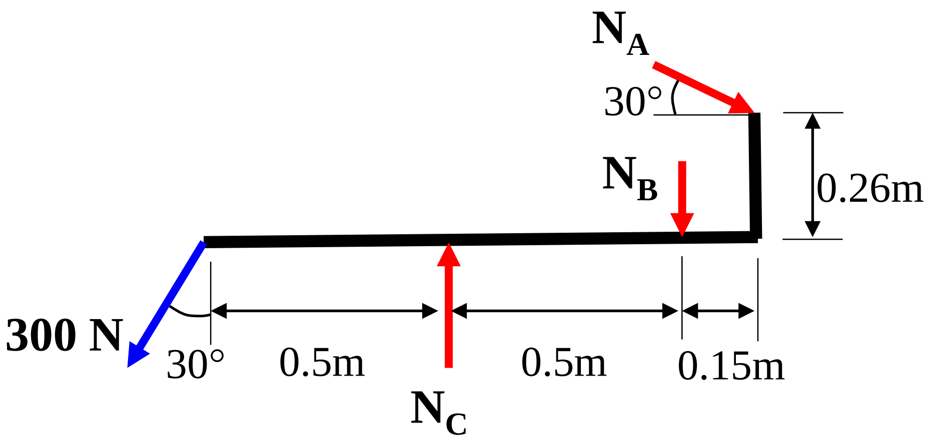
Draw:

A FBD of the smooth pipe which rests against the opening at the points of contact *A*, *B*, and *C*.

GROUP PROBLEM SOLVING I (continued)



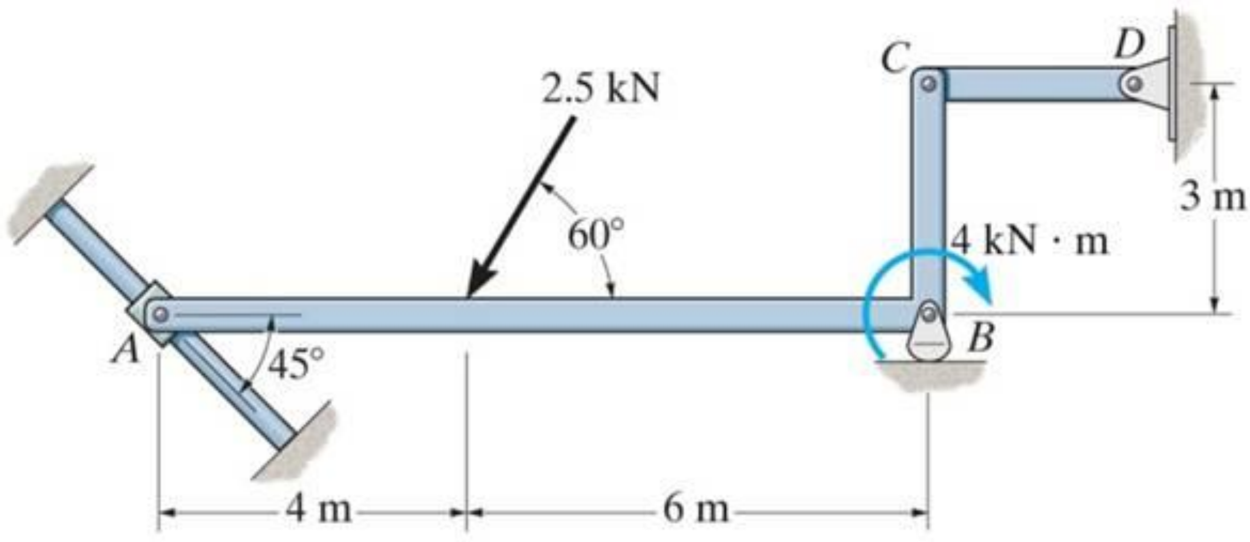
The idealized model



The free-body diagram

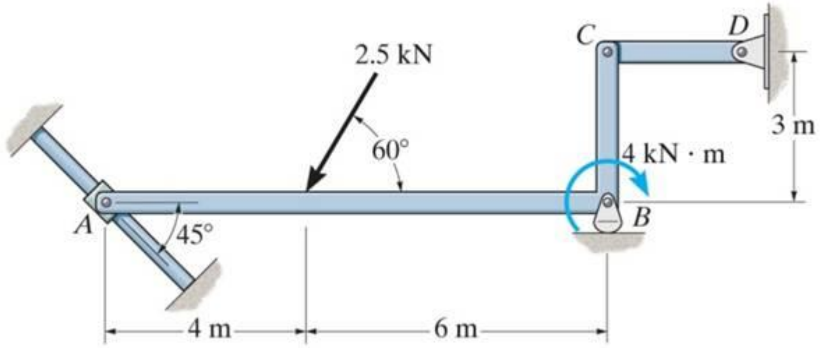
GROUP PROBLEM SOLVING II

Given:

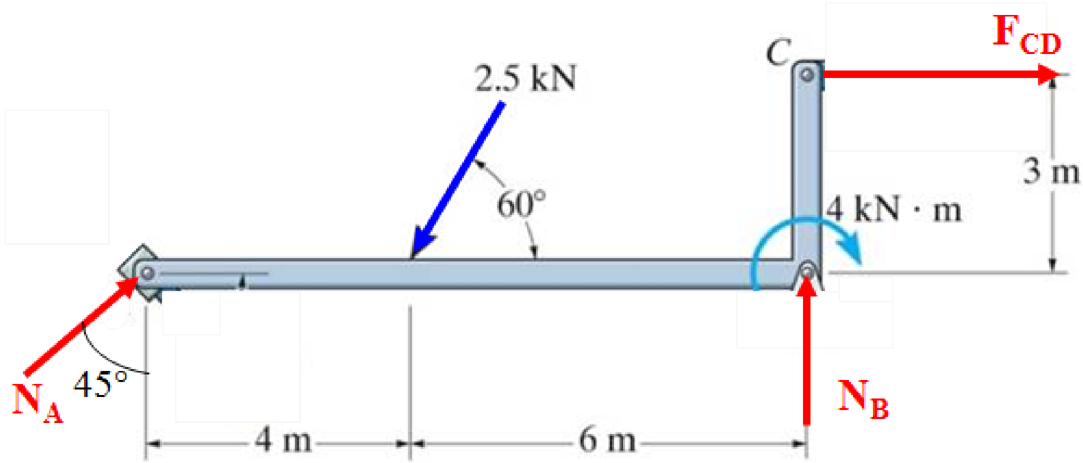


Draw: Draw a FBD of member ABC, which is supported by a smooth collar at A, roller at B, and link CD.

GROUP PROBLEM SOLVING II (continued)



The idealized model



The free-body diagram

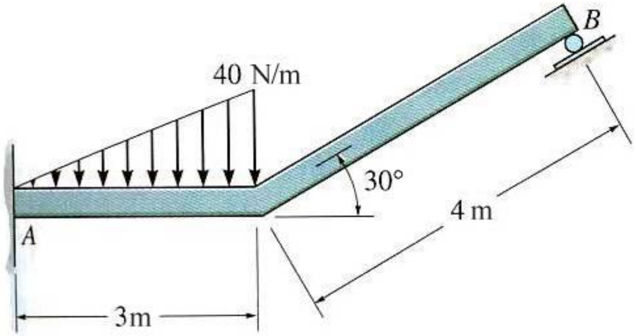
ATTENTION QUIZ

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?

   A) Two forces and two couple moments
   B) One force and two couple moments
   C) Three forces
   D) Three forces and one couple moment



End of the Lecture

Let Learning Continue