EQUILIBRIUM OF A RIGID BODY & FREE-BODY DIAGRAMS

Today's Objectives:

Students will be able to:

a) Identify support reactions, and,

b) [illegible]n.

In-Class Activities:

- Check Homework
- Reading Quiz
- Applications
- Support Reactions
- Free – Body Diagram
- 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.

   1) couple moment

   2) force

   3) Both A and B.

   4) None of the above

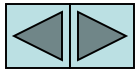
2. Internal forces are _____ shown on the free body diagram of a whole body.

   A) always

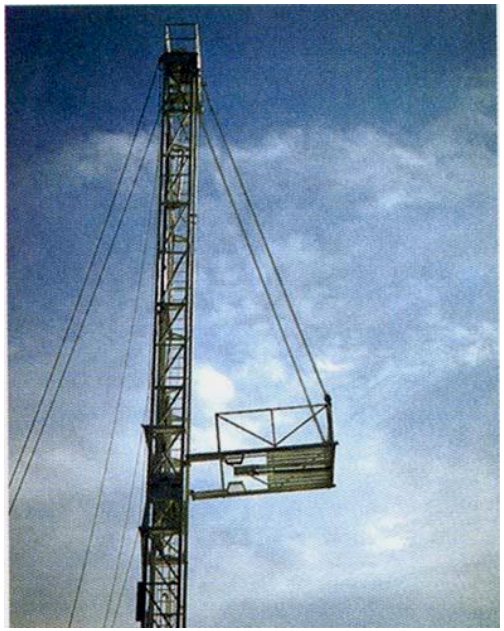
   B) often

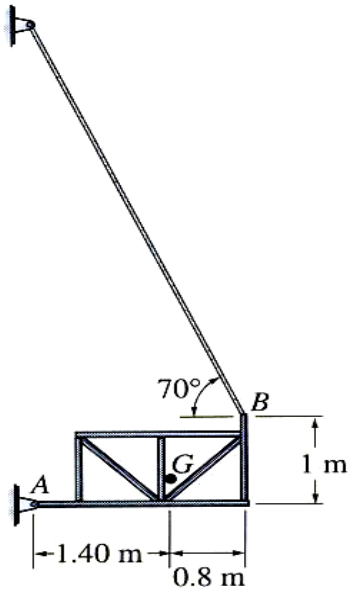
   C) rarely

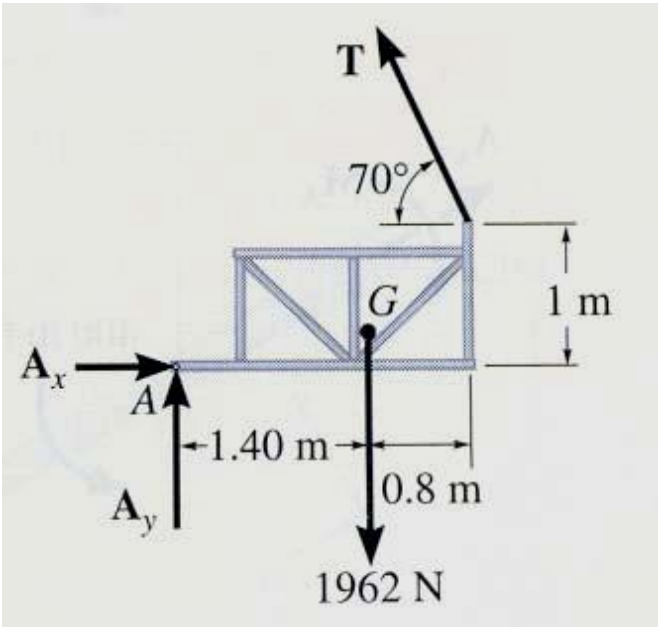
   D) never



APPLICATIONS



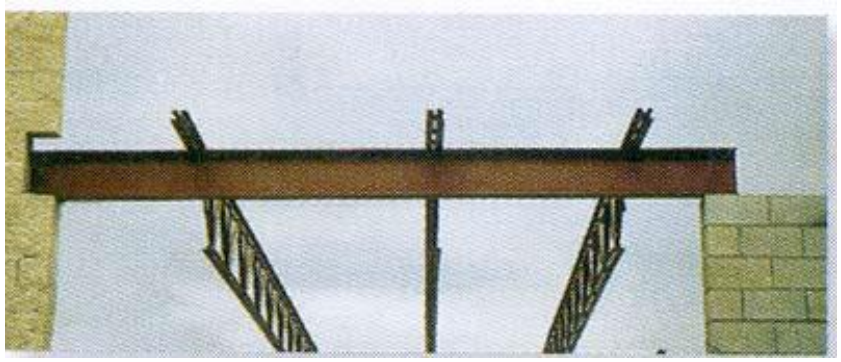




A 200 kg platform is suspended off an oil rig. How do we determine the force reactions at the joints and the forces in the cables?

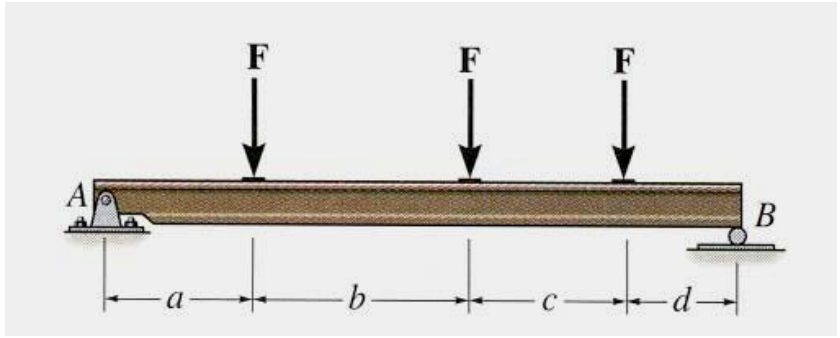
How are the idealized model and the free body diagram used to do this? Which diagram above is the idealized model?

APPLICATIONS
(continued)



A steel beam is used to support roof joists.

How can we determine the support reactions at A & B?



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

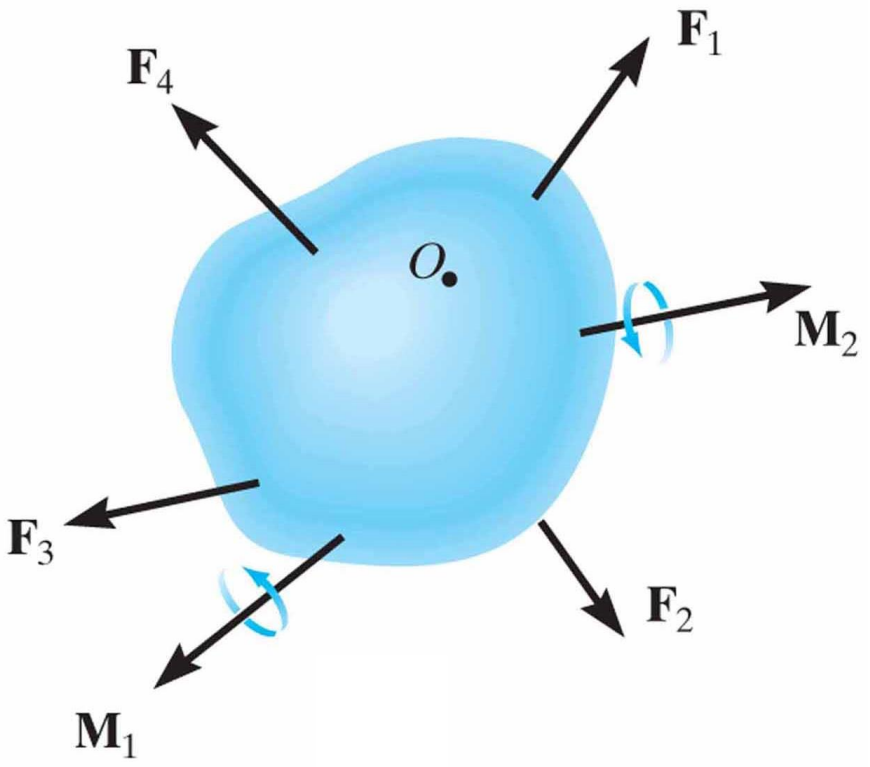
Rigid Body Equilibrium (Ch 5)

- Equilibrium = moving at constant or zero velocity
- Rigid = negligible deformation under load
- Body = forces not necessarily concurrent

Requirements:

$$\sum \vec{F} = 0$$

$$\sum \vec{M}_P = 0$$



Scalar Equations in 3D

$$\sum \vec{F} = 0 \Rightarrow \sum F_x = 0 \quad \sum F_y = 0 \quad \sum F_z = 0$$

$$\sum \vec{M}_P = 0 \Rightarrow \sum M_{Px} = 0 \quad \sum M_{Py} = 0 \quad \sum M_{Pz} = 0$$

6 equations → **6 unknowns** that can be solved for a single rigid body in 3D

Scalar Equations in 2D (coplanar forces)

$$\sum \vec{F} = 0 \quad \Rightarrow \quad \sum F_x = 0 \qquad \sum F_y = 0$$

$$\sum \vec{M}_P = 0 \quad \Rightarrow \qquad \sum M_{Pz} = 0$$

3 equations → **3 unknowns** that can be solved for a single rigid body in 2D

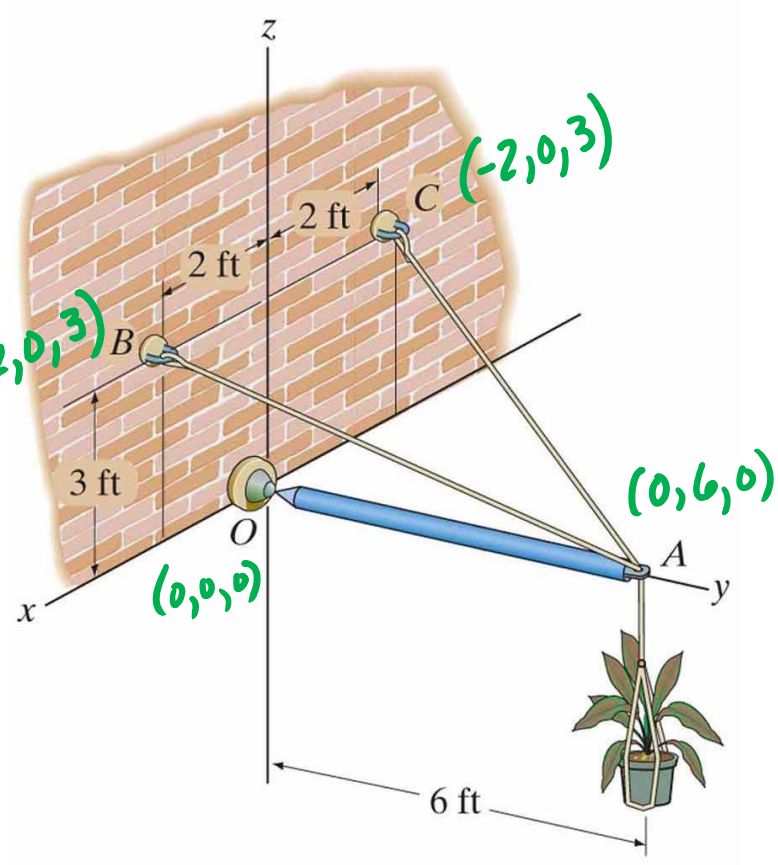
Other Equivalent Equation Sets in 2D

$\sum F_x = 0$	$\sum M_{Az} = 0$	$\sum M_{Bz} = 0$
$\sum F_y = 0$	$\sum M_{Az} = 0$	$\sum M_{Bz} = 0$
$\sum M_{Az} = 0$	$\sum M_{Bz} = 0$	$\sum M_{Cz} = 0$

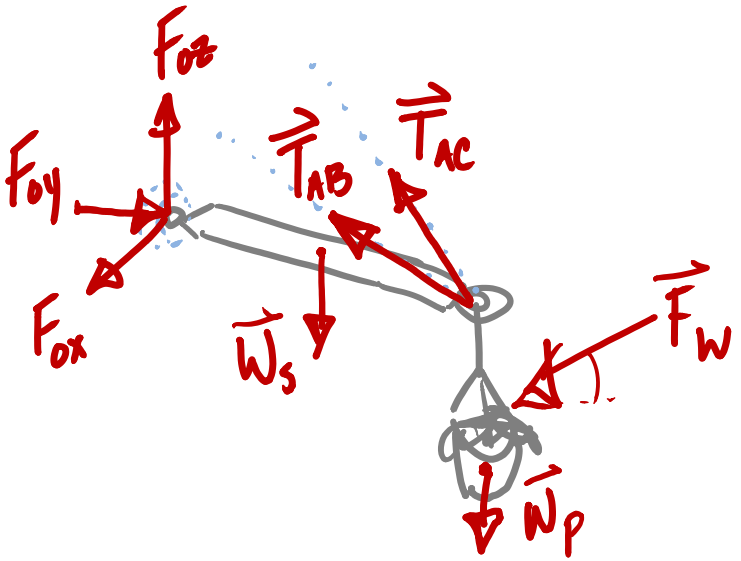
- 3 equations → **3 unknowns**
- Some restrictions for these alternate forms (later)

Free-Body Diagram (FBD)

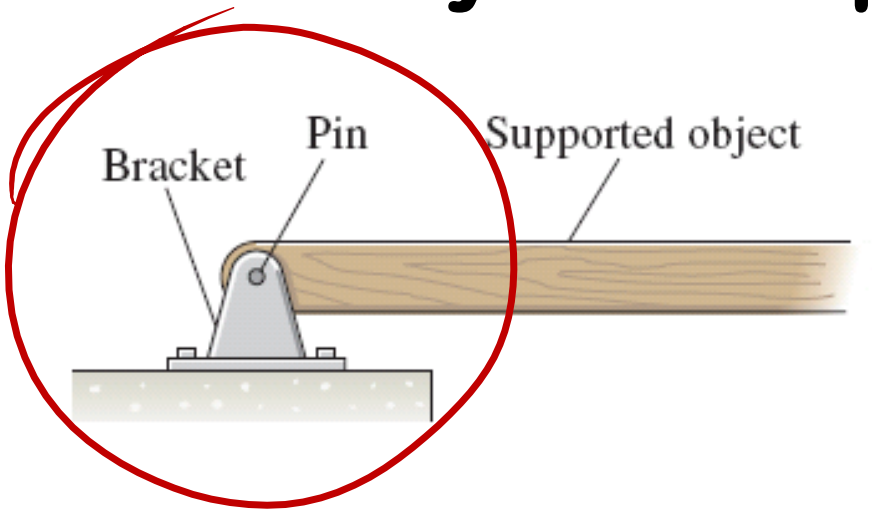
- Drawing of an object (or group of objects) showing **all external** forces acting on it.



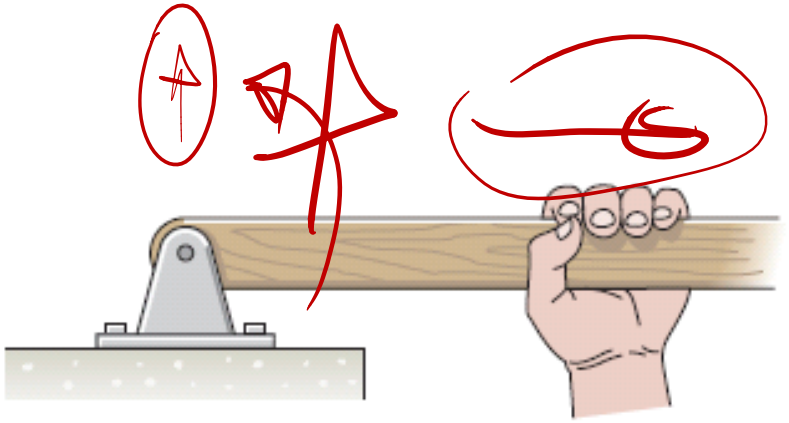
1. Isolate body
2. Show Forces
   - Body (gravity)
   - Applied (usually given)
   - Reactions (the hard part)
3. Identify Forces



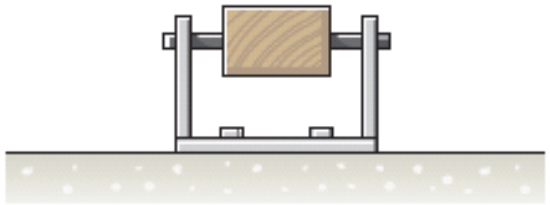
Analysis of Support Reactions

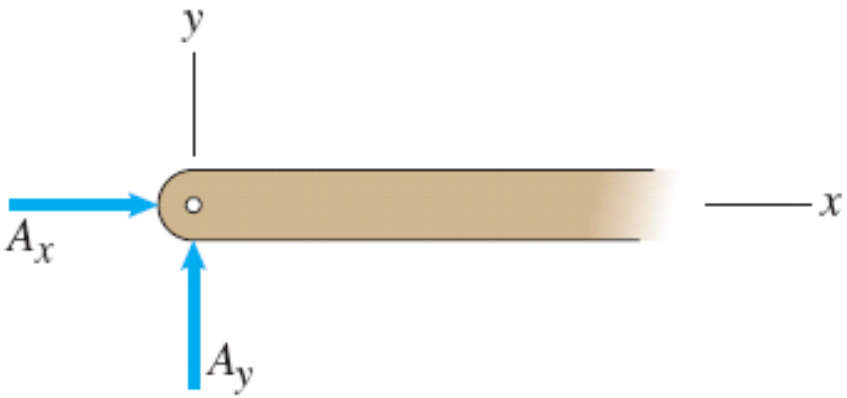


Analyze support structure



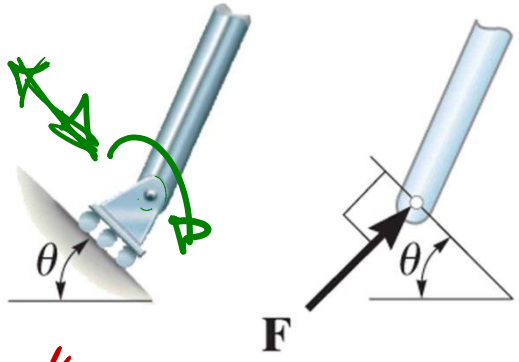
Imagine which types of motion it restricts.



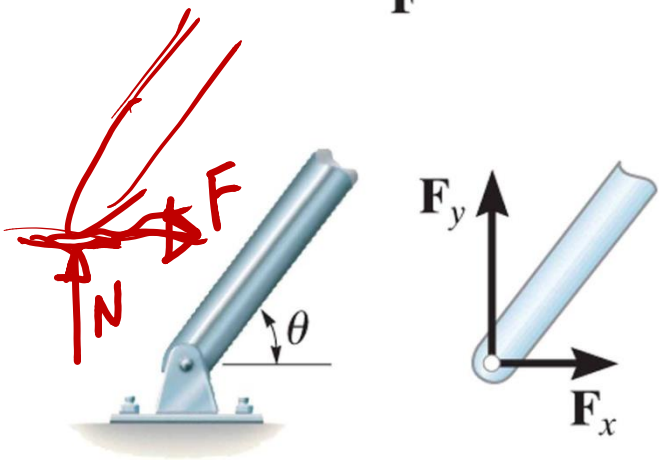


Replace it with reaction forces to represent these restrictions.

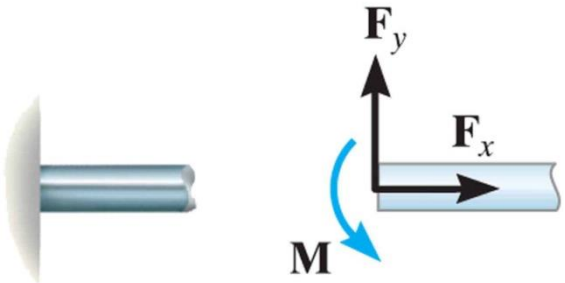
Support Reactions in 2D



roller, rocker, smooth surface
single F normal to surface



(smooth) pin, rough surface
F_x and F_y or F and angle

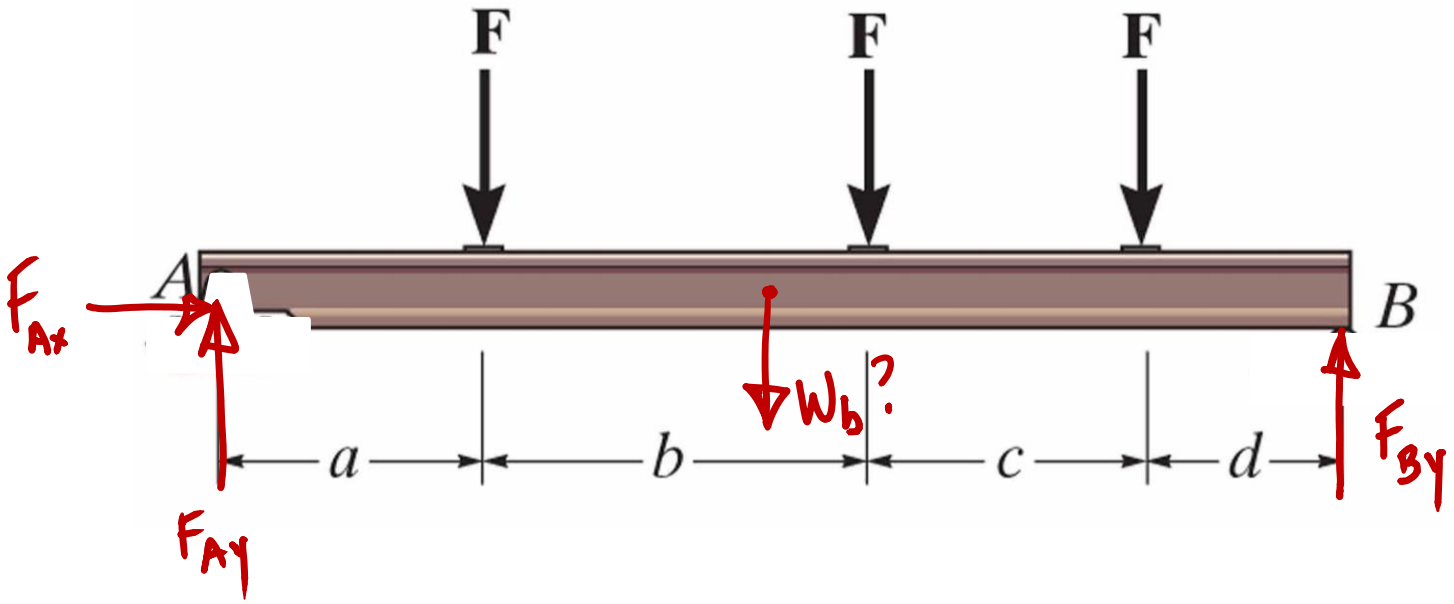


fixed support
F_x, F_y, and M

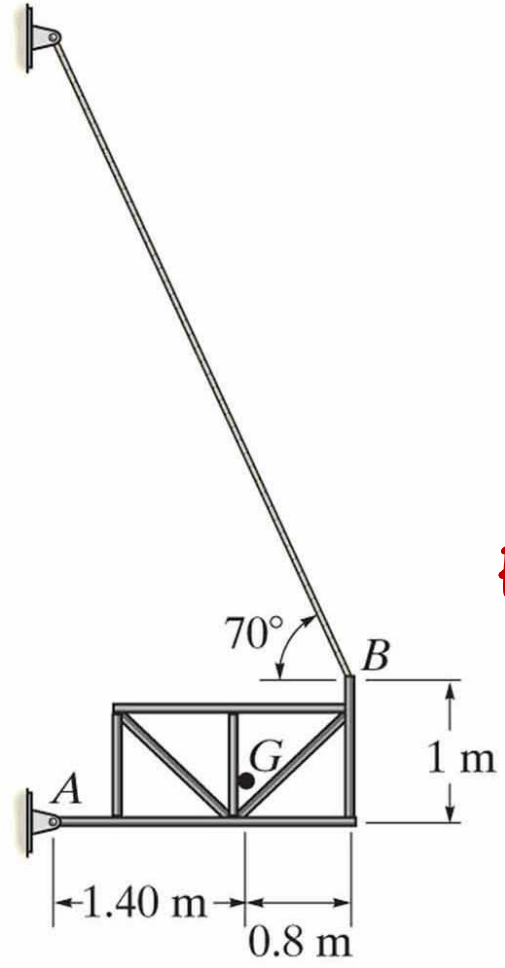
*more complete table in text

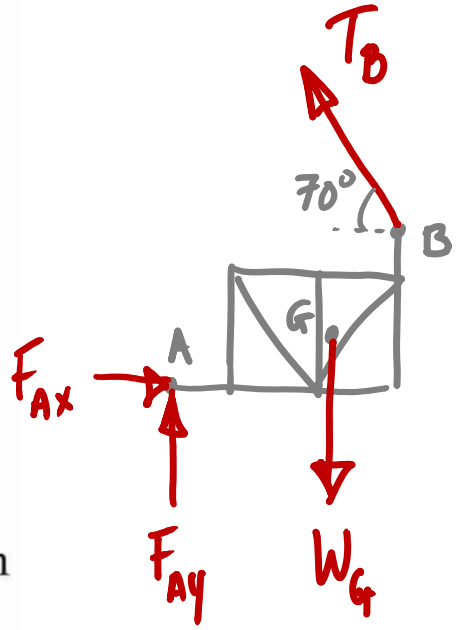
Real Supports

FBD Example 1 in 2D

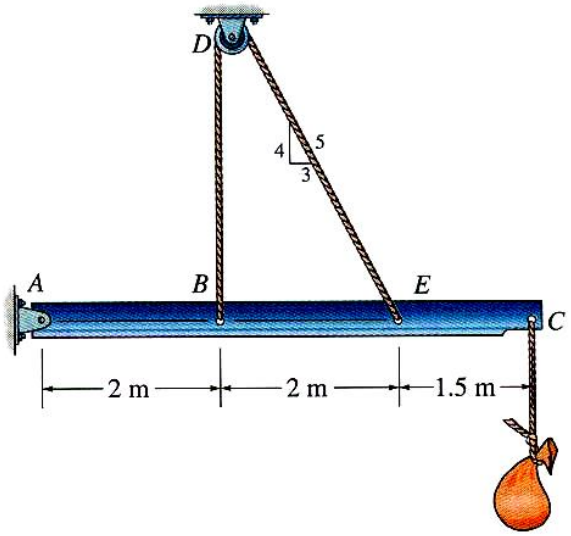


FBD Example 2 in 2D



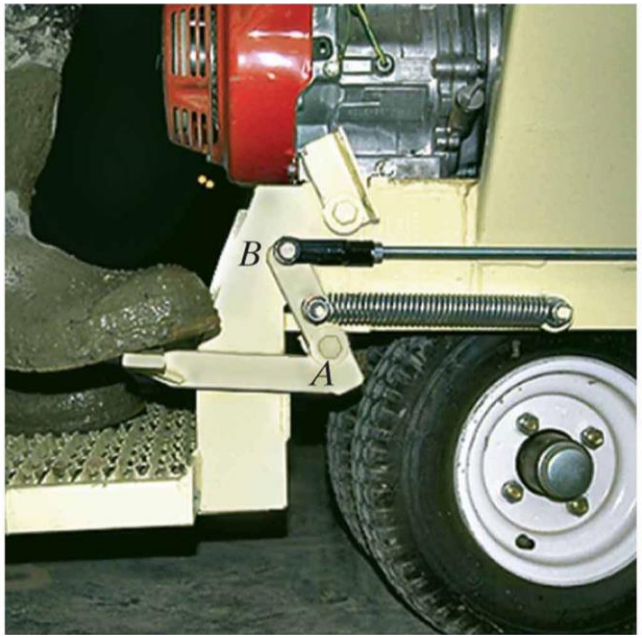


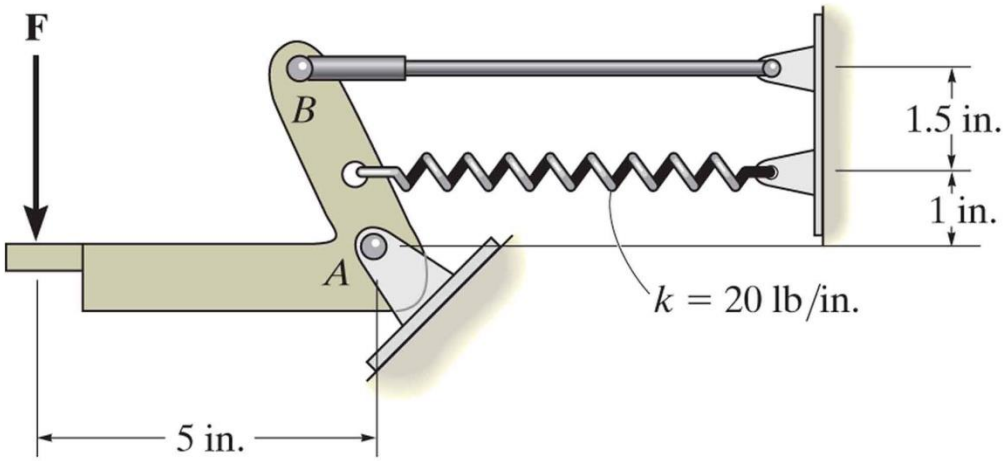
CONCEPT QUIZ



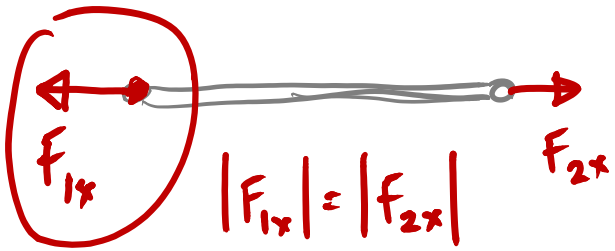
1. The beam and the cable (with a frictionless pulley at D) support an 80 kg load at C. In a FBD of only the beam, there are how many unknowns?
   1) 2 forces and 1 couple moment
   2) 3 forces and 1 couple moment
   3) 3 forces
   4) 4 forces

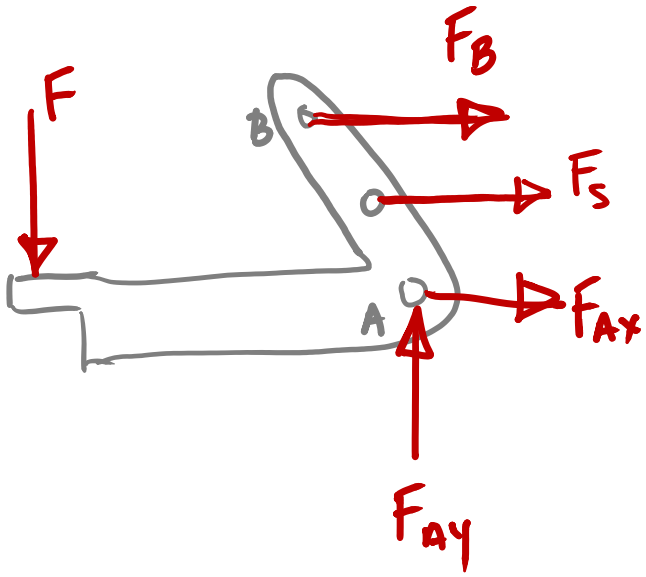
FBD Example 3 in 2D



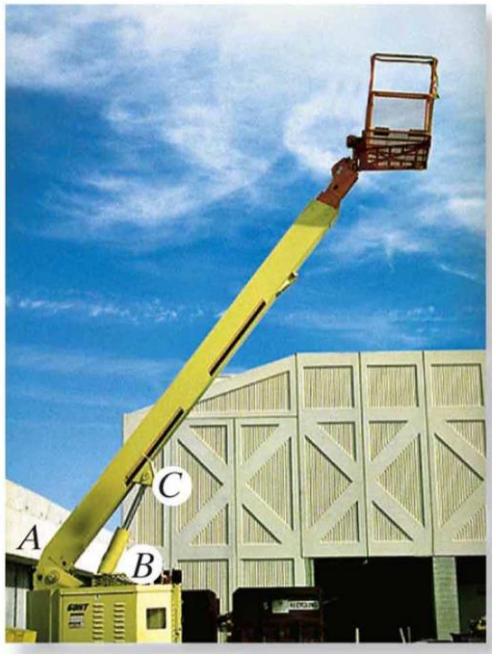


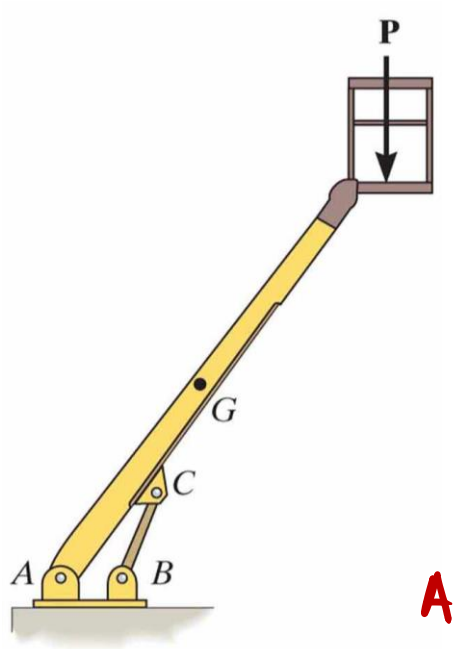
2F member

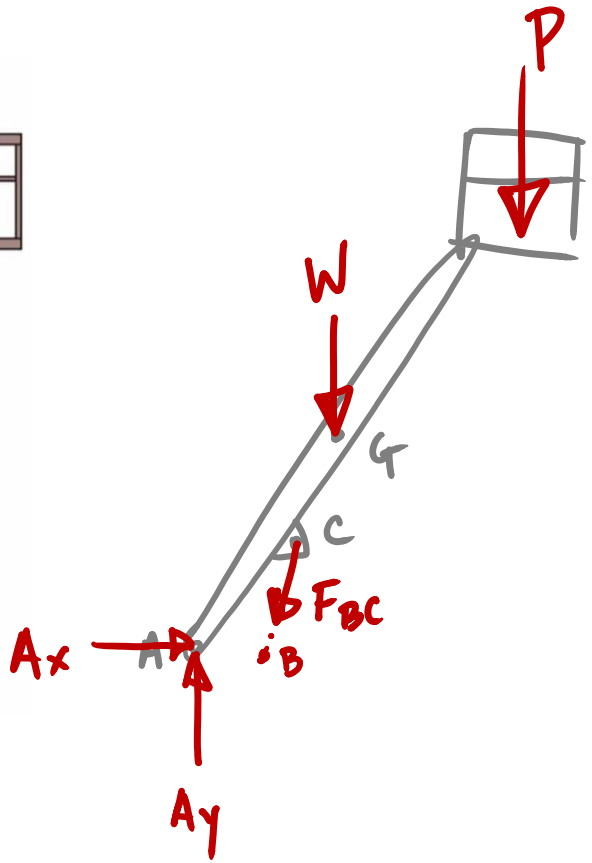




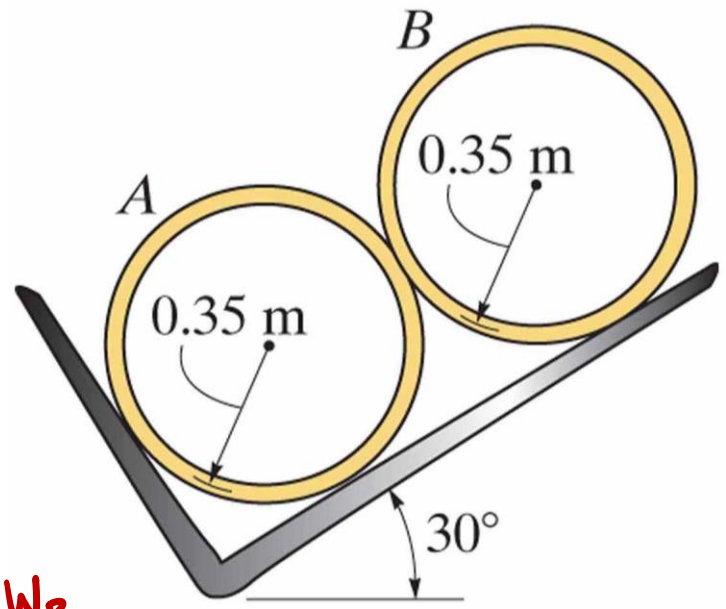
FBD Example 4 in 2D

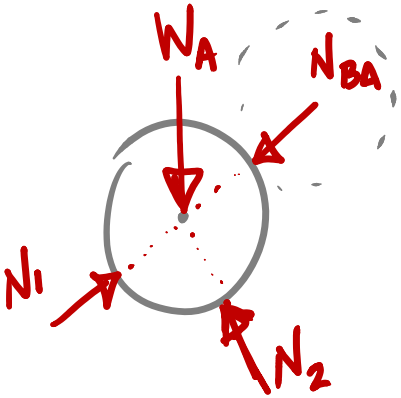


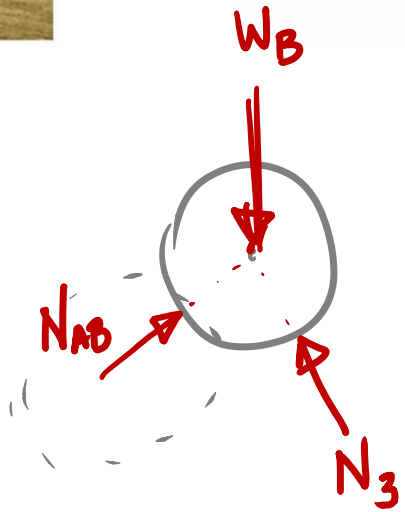


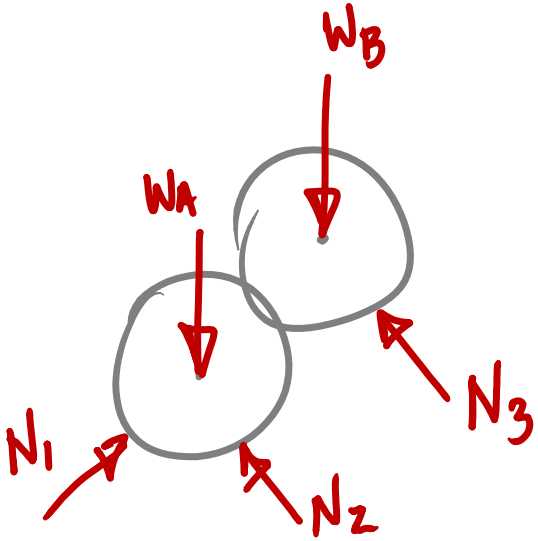


FBD Example 5 in 2D









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