

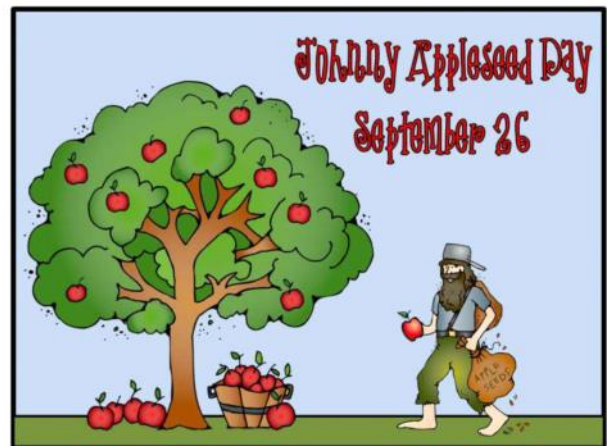
Announcements

- Quiz 2 starts tomorrow ~
- Free study day Friday (9/28 – no class 😊)

□ Upcoming deadlines:

- Friday (9/28)
 - Written Assignment
- Tuesday (10/2)
 - PL HW

1

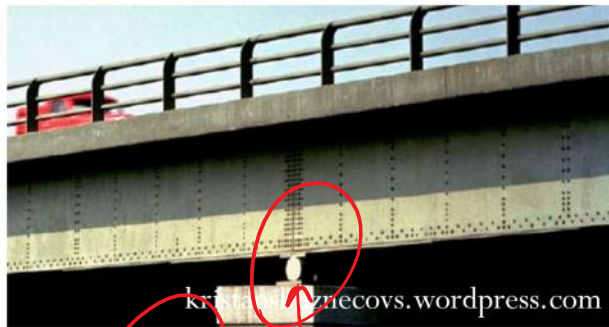


Objective

- Free body diagram for 2D rigid body
- Types of constraints
- Equations of equilibrium for 2D rigid body

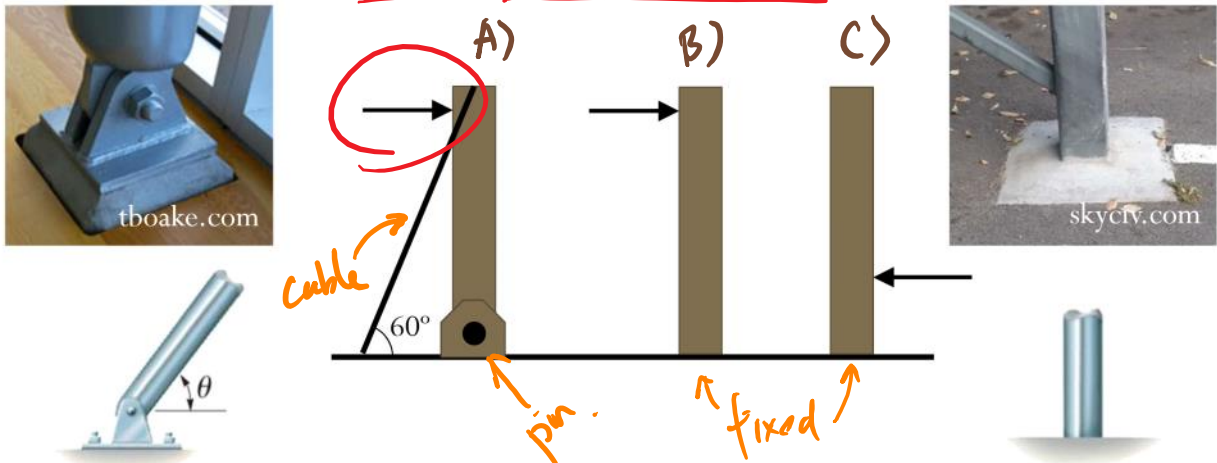
Equilibrium in two-dimensional bodies

Why different support?

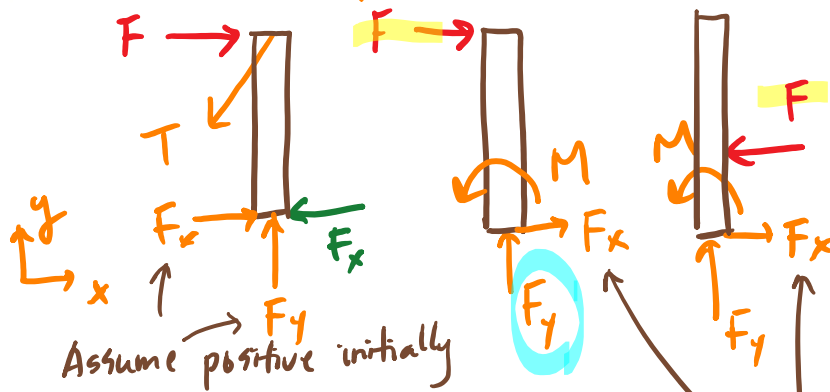


Equilibrium in two-dimensional bodies

Active Forces vs. Support reaction components



6



$$\sum F_x = F + F_x = 0$$

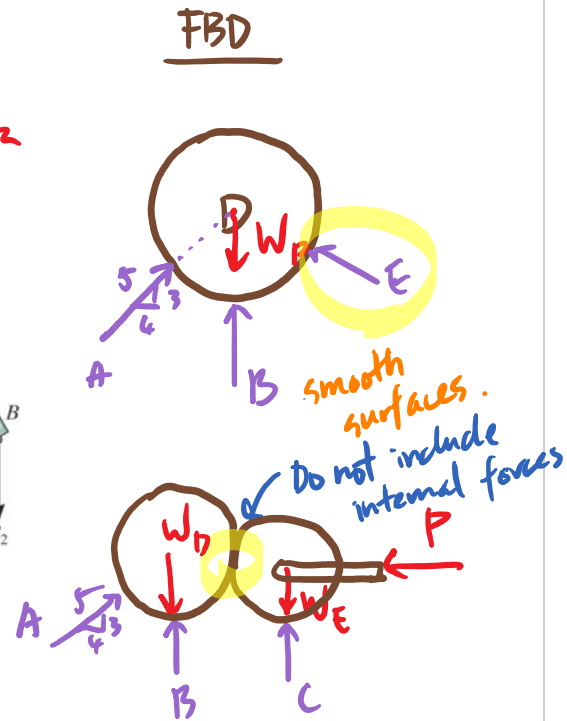
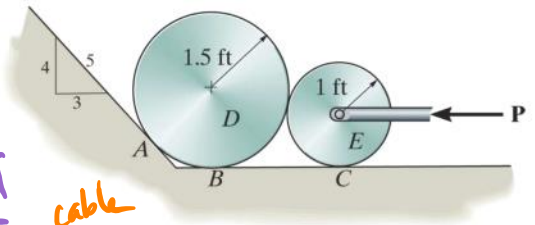
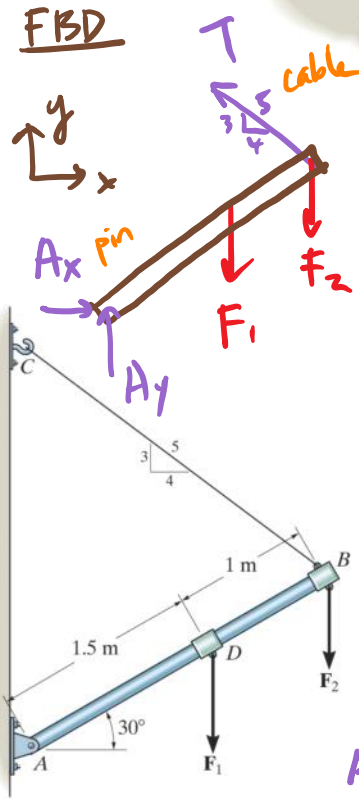
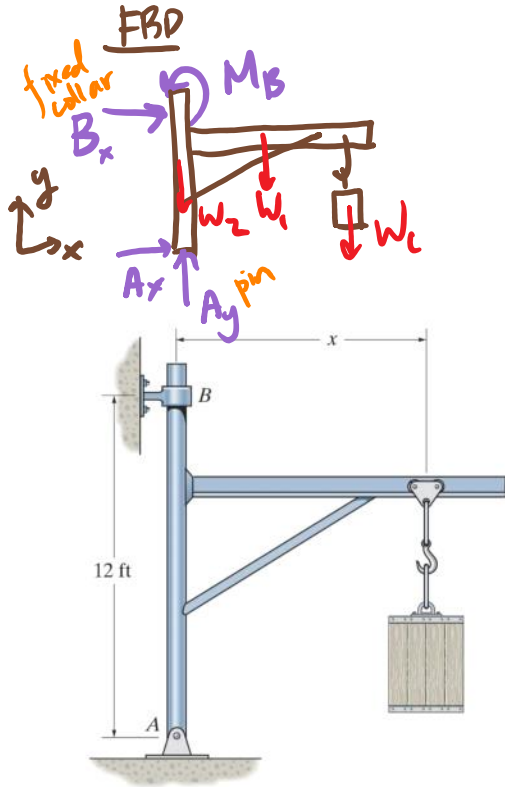
$\rightarrow F_x = -F$ Then negative value correspond to negative direction.

$$\sum F_x = F - F_x = 0$$

$F_x = F$ Otherwise, you have to keep track the direction separately.

Always assume positive direction initially, independent of external loadings.

Free Body Diagrams



Constraints

To ensure equilibrium of a rigid body, it is not only necessary to satisfy equations of equilibrium, but the body must also be properly constrained by its supports

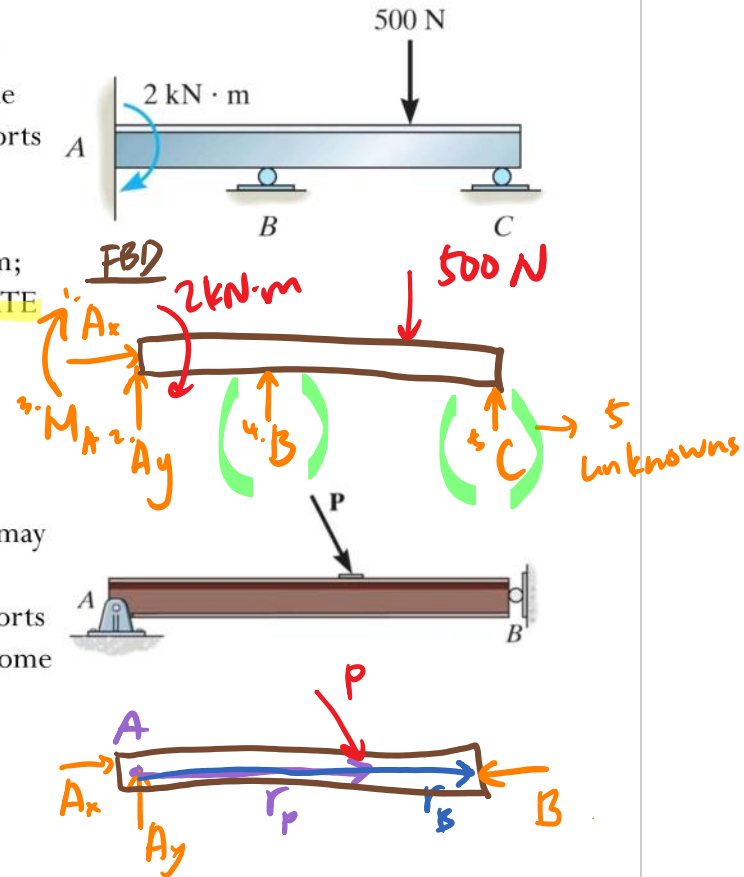
- Redundant constraints:** the body has more supports than necessary to hold it in equilibrium; the problem is **STATICALLY INDETERMINATE** and **cannot be solved with statics alone**

Sometimes extra supports are needed for safety.






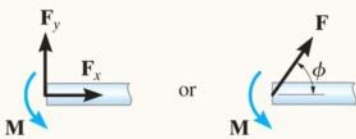
$$\begin{aligned} \sum F_x &= 0 & \sum M_A &= 0 \\ \sum F_y &= 0 & \rightarrow & 3 \text{ equations} \end{aligned}$$

Improper constraints: In some cases, there may be as many unknown reactions as there are equations of equilibrium. However, if the supports are not properly constrained, the body may become unstable for some loading cases.

$$\sum \vec{M}_A = \vec{r}_P \times \vec{P} + \vec{r}_B \times \vec{B} \neq 0$$



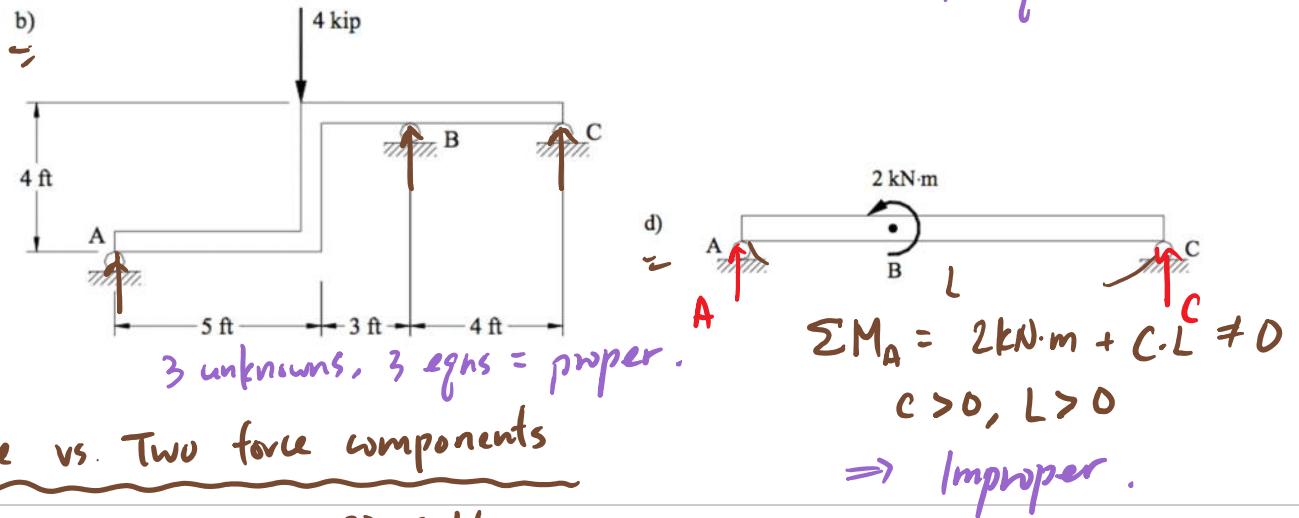
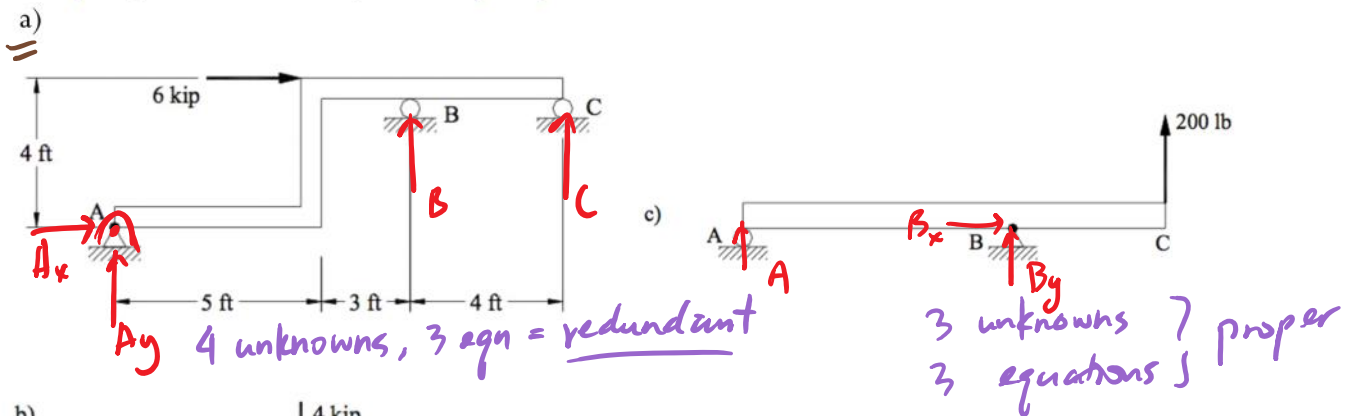
Types of connectors

| TABLE 5-1 Continued | | |
|--|--|---|
| Types of Connection | Reaction | Number of Unknowns |
| <p>(8)</p>  <p>smooth pin or hinge</p> |  | <p>Two unknowns. The reactions are two components of force, or the magnitude and direction ϕ of the resultant force. Note that ϕ and θ are not necessarily equal [usually not, unless the rod shown is a link as in (2)].</p> |
| <p>(9)</p>  <p>member fixed connected to collar on smooth rod</p> |  | <p>Two unknowns. The reactions are the couple moment and the force which acts perpendicular to the rod.</p> |
| <p>(10)</p>  <p>fixed support</p> |  | <p>Three unknowns. The reactions are the couple moment and the two force components, or the couple moment and the magnitude and direction ϕ of the resultant force.</p> |

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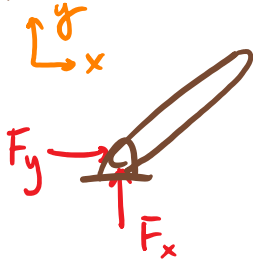
Constraints

Proper, redundant, or improper constraints



One vs. Two force components

A) Pin



$$\Sigma F_x = F_x$$

$$\Sigma F_y = F_y$$

Two different "components" show up in a system

B) Cable



$$\Sigma F_x = T_x = -T \cos 60^\circ$$

$$\Sigma F_y = T_y = T \sin 60^\circ$$

only 1 "component" show up in the system of equations.

"components"
up in the system
of equations.