Announcements

- Quiz 2 this week
- No class Friday (9/28/18) ☺

❑ Upcoming deadlines:

- Tuesday (9/24)
  - PL HW
- Friday (9/28)
  - Written Assignment

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Chapter 5: Equilibrium of Rigid Bodies

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Goals and Objectives

- Analysis procedure for a rigid body at equilibrium
- Identify support reactions

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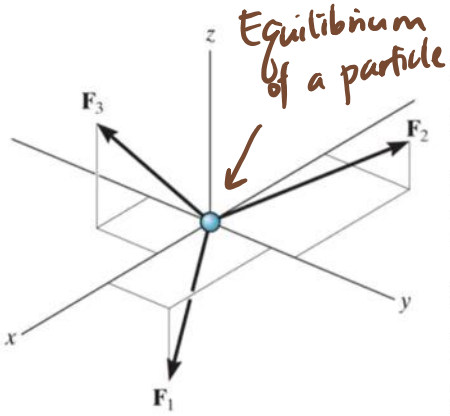
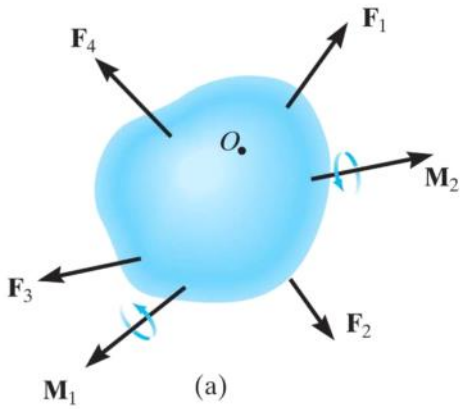
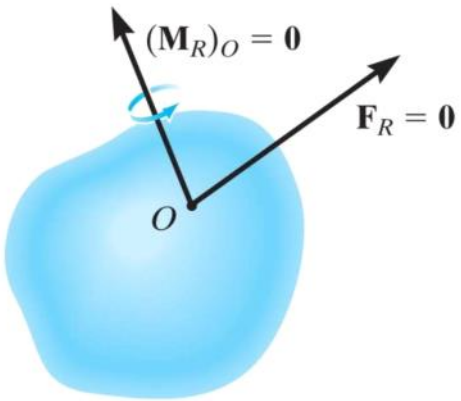
Equilibrium of a Rigid Body



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. We can reduce the force and couple moment system acting on a body to an equivalent resultant force and a resultant couple moment at an arbitrary point O.





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Equilibrium of a Rigid Body

Static equilibrium:

$\Sigma \vec{F} = 0$ ~ no translation

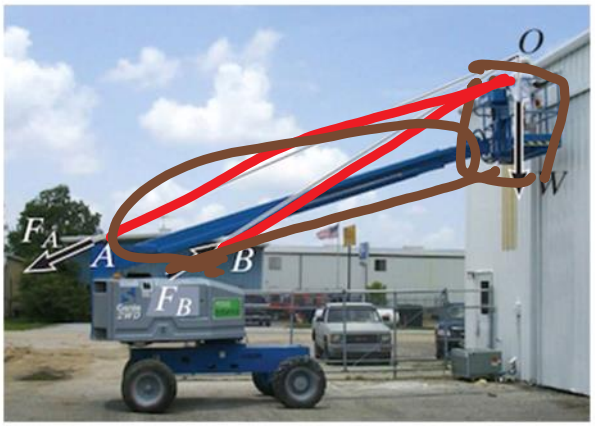
$\Sigma \vec{M} = 0$ ~ no rotation

Maintained by reaction forces and moments

- entities provided by connections to constraint (support) the body in order to maintain equilibrium

Assumption of rigid body

- members don't break / deform during the process of analysis.



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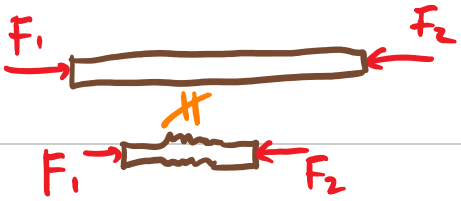

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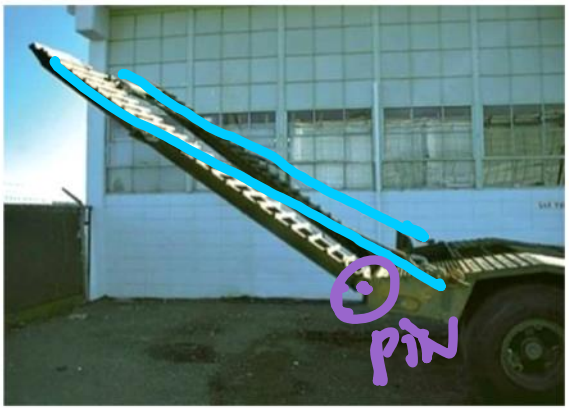
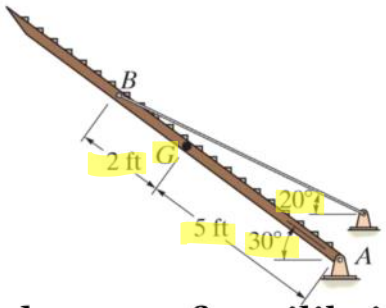
Process of solving rigid body equilibrium problems

The uniform truck ramp has weight 400 lb and is pinned to the body of the truck at each side and held in the position shown by the two side cables. Determine the reaction forces at the pins and the tension in the cables.



1. Create idealized model (modeling and assumptions)



2. Draw free body diagram showing ALL the external (applied loads and supports)

3. Apply eqns of equilibrium

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

$$\Sigma \vec{M} = 0$$

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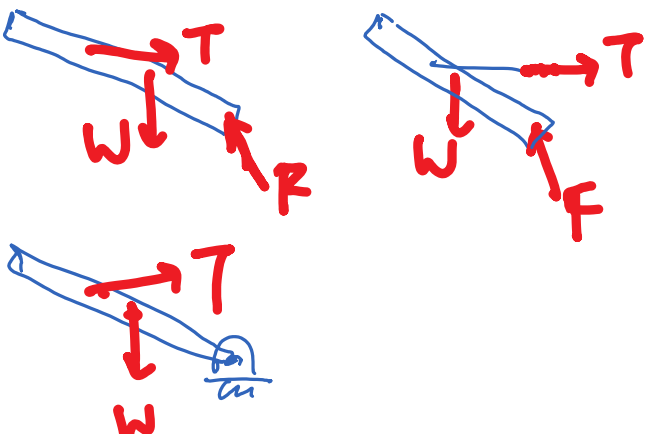
FBD

* Identify the "body"
* Identify external forces
* Provide coordinate system & geometry



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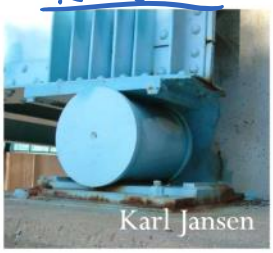
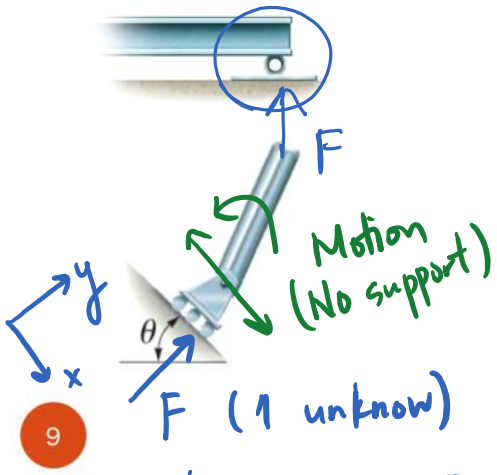
Equilibrium in two-dimensional bodies

Support reactions

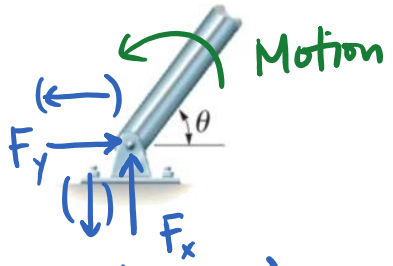
Roller





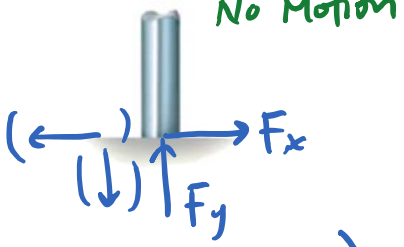
F (1 unknow)

Pin



(2 unknowns)

Fixed



(3 unknowns)

- Force in 2D has 2 unknowns =
  a) Cartesian: F_x, F_y
  b) magnitude/direction: $\vec{F}$, $\hat{u}$

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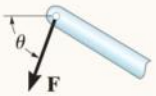
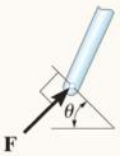
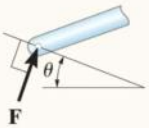
Types of connectors

TABLE 5–1 Supports for Rigid Bodies Subjected to Two-Dimensional Force Systems

Types of Connection	Reaction	Number of Unknowns
(1)  cable	 1 force component only	One unknown. The reaction is a tension force which acts away from the member in the direction of the cable.
(2)  weightless link	 or	One unknown. The reaction is a force which acts along the axis of the link.
(3)  roller		One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.
(4)  rocker		One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.

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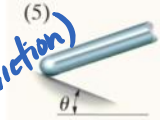
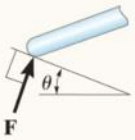
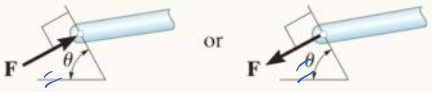
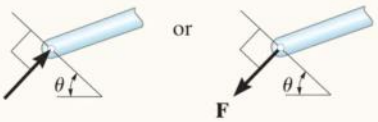
Types of connectors

TABLE 5–1 Supports for Rigid Bodies Subjected to Two-Dimensional Force Systems

Types of Connection	Reaction	Number of Unknowns
(5)  smooth contacting surface		One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.
(6)  roller or pin in confined smooth slot		One unknown. The reaction is a force which acts perpendicular to the slot.
(7)  member pin connected to collar on smooth rod		One unknown. The reaction is a force which acts perpendicular to the rod.

continued

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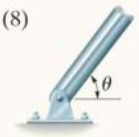
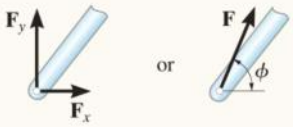
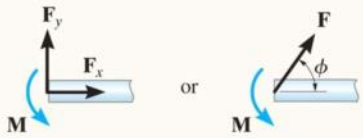
Types of connectors

TABLE 5–1 Continued

Types of Connection	Reaction	Number of Unknowns
(8)  smooth pin or hinge		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)].
(9)  member fixed connected to collar on smooth rod		Two unknowns. The reactions are the couple moment and the force which acts perpendicular to the rod.
(10)  fixed support		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.

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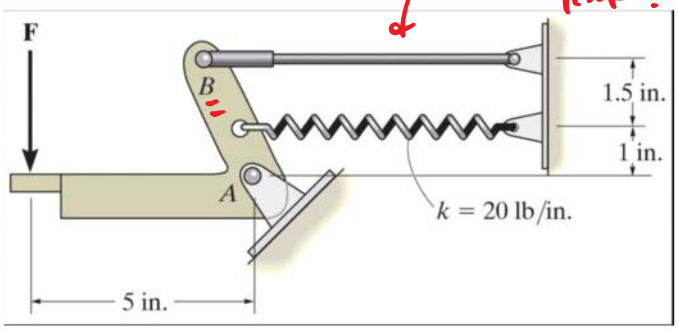
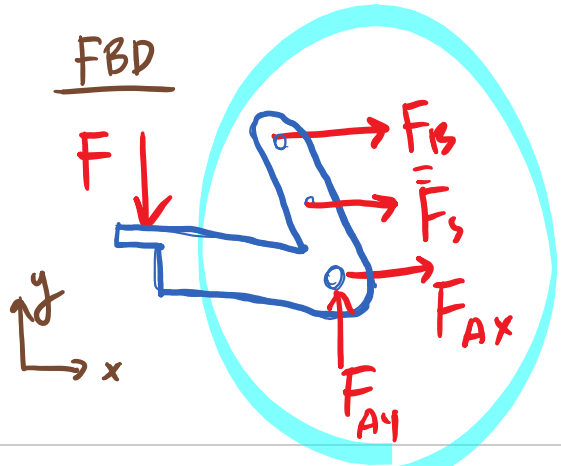
The operator applies a vertical force to the pedal so that the spring is stretched 1.5 in. and the force in the short link at B is 20 lb. Determine the vertical force applied to the pedal.

weightless link.



If you don't identify support reactions properly, you'll end up with a mess

FBD



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- Assume body mass is negligible

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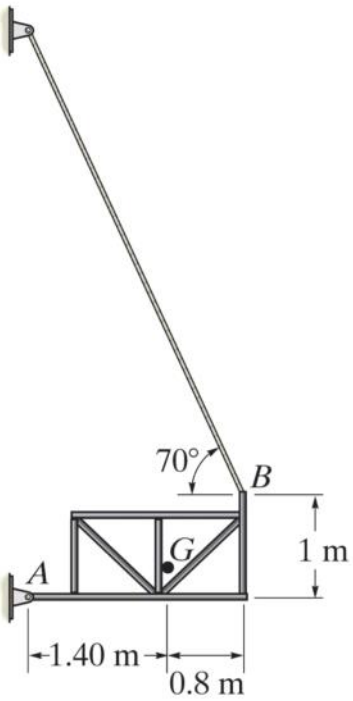
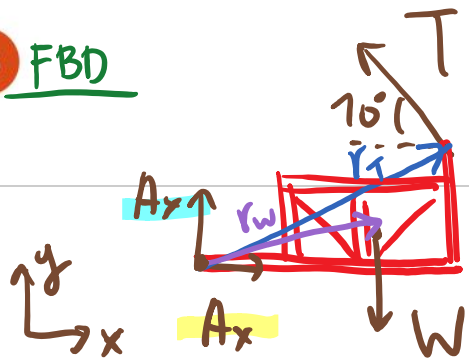
Find the tension in cable B given the weight of the cage.



16 FBD



Equations of Equilibrium

$$\Sigma F_x = 0 = A_x - T\cos 70^\circ = 0$$

$$\Sigma F_y = 0 = A_y + T\sin 70^\circ - W$$

$$\Sigma \vec{M}_A = 0 = \vec{r}_W \times \vec{W} + \vec{r}_T \times \vec{T}$$