Announcements

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

- Upcoming deadlines:
  - Tuesday (9/24)
    - PL HW
  - Friday (9/28)
    - Written Assignment
Chapter 5: Equilibrium of Rigid Bodies
Goals and Objectives

- Analysis procedure for a rigid body at equilibrium
- Identify support reactions
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 $O$. 
Equilibrium of a Rigid Body

Static equilibrium:
\[ \Sigma F = 0 \quad \text{no translation} \]
\[ \Sigma M = 0 \quad \text{no rotation} \]
Maintained by reaction forces and moments

- entries provided by connections to constraint (support) the body in order to maintain equilibrium
- members don't break/deform during the process of analysis.
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

\[ \sum F = 0 \]
\[ \sum \vec{M} = 0 \]
Equilibrium in two-dimensional bodies

Support reactions

- Roller
- Pin
- Fixed

Support reactions:

- Roller: No support (1 unknown)
- Pin: Motion (2 unknowns)
- Fixed: No Motion (3 unknowns)

Motion:

- Force in 2D has 2 unknowns:
  a) Cartesian: $F_x, F_y$
  b) magnitude/ direction: $F, \theta$

Images from:
- Karl Jansen
- tboake.com
- skyctv.com
### Types of Connectors

<table>
<thead>
<tr>
<th>Types of Connection</th>
<th>Reaction</th>
<th>Number of Unknowns</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) cable</td>
<td><img src="" alt="Diagram of a cable" /></td>
<td>One unknown. The reaction is a tension force which acts away from the member in the direction of the cable.</td>
</tr>
<tr>
<td>(2) weightless link</td>
<td><img src="" alt="Diagram of a weightless link" /></td>
<td>One unknown. The reaction is a force which acts along the axis of the link.</td>
</tr>
<tr>
<td>(3) roller</td>
<td><img src="" alt="Diagram of a roller" /></td>
<td>One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.</td>
</tr>
<tr>
<td>(4) rocker</td>
<td><img src="" alt="Diagram of a rocker" /></td>
<td>One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.</td>
</tr>
</tbody>
</table>

*Note: Diagrams not included in this text representation.*
Types of connectors

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<tr>
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<tr>
<td>Smooth contacting surface</td>
<td>![Diagram](No Friction)</td>
<td>One unknown. The reaction is a force which acts perpendicular to the surface at the point of contact.</td>
</tr>
<tr>
<td>Roller or pin in confined smooth slot</td>
<td>![Diagram](smooth slot)</td>
<td>One unknown. The reaction is a force which acts perpendicular to the slot.</td>
</tr>
<tr>
<td>Member pin connected to collar on smooth rod</td>
<td>![Diagram](smooth rod)</td>
<td>One unknown. The reaction is a force which acts perpendicular to the rod.</td>
</tr>
</tbody>
</table>

(continued)
## Types of Connectors

### Table 5-1 Continued

<table>
<thead>
<tr>
<th>Types of Connection</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Smooth pin or hinge</td>
<td></td>
<td>Two unknowns. The reactions are two components of force, or the magnitude and direction ( \phi ) of the resultant force. Note that ( \phi ) and ( \theta ) are not necessarily equal [usually not, unless the rod shown is a link as in (2)].</td>
</tr>
<tr>
<td>Member fixed connected to collar on smooth rod</td>
<td></td>
<td>Two unknowns. The reactions are the couple moment and the force which acts perpendicular to the rod.</td>
</tr>
<tr>
<td>Fixed support</td>
<td></td>
<td>Three unknowns. The reactions are the couple moment and the two force components, or the couple moment and the magnitude and direction ( \phi ) of the resultant force.</td>
</tr>
</tbody>
</table>
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.

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

Assume body mass is negligible
Find the tension in cable B given the weight of the cage.

\[ \Sigma F_x = 0 = A_x - T \cos 70^\circ = 0 \]
\[ \Sigma F_y = 0 = A_y + T \sin 70^\circ - W \]
\[ \Sigma M_A = 0 = \vec{r}_w \times \vec{W} + \vec{r}_T \times \vec{T} = 0 \]