Housekeeping

- Tuesday
  - PL HW 10
  - Quiz 3 starts
- Thursday
  - ME HW 11
- Saturday
  - Last quiz day
- Sunday
  - WA due
- Tuesday
  - PL HW 12

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- Piazza posts - private office hours

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Lateral Pain 2
- Foot internally rotated
- Lateral pain
- SOLUTION: Rotate cleat to point toes outward

Medial Pain 2
- Foot externally rotated
- Medial pain
- SOLUTION: Rotate cleat to point toes inward

Cause? Reaction forces! (internal)
Forces on members vs pins

"Try" athlete

3D version but need both parts of fork above
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.

- **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.

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**What if we take EMA?**

- the effect of external loads are constrained
\[\begin{align*}
\text{\textbf{Slide 3}}
\end{align*}\]

\[\begin{align*}
&\text{\textbf{EF}_x: } A_x = 0 \\
&\text{\textbf{EF}_y: } A_y - B_y - C_y - 500N = 0 \\
&\text{\textbf{EMA: } } B_y d_1 - (500N d_2) + (C_y)(d_3) - 2 \text{ kN} \cdot \text{m} = 0
\end{align*}\]

**Q:** Why would a structure have more constraints than necessary based on static equilibrium?

**A:** Redundancy, safety, how to solve?
\[ \sum_{A} P_y \, d = 0 \]

Reflect: This can only be true if \( P_y = 0 \)

What happens if \( P \) exists?

- There will be a moment about \( A \) that is not balanced by any constraints.

What constraint type could solve this?

- Several options, but a fixed support is easier/better
Equilibrium of a rigid body – 3D!

Now we add the z axis

6 Equations of Equilibriums

\[ 3F_x = 3F_y = 3F_z = 0 \]

\[ 3M_x = 3M_y = 3M_z = 0 \]

Possible now to have 6 unknowns
<table>
<thead>
<tr>
<th>Types of Connection</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) cable</td>
<td></td>
</tr>
<tr>
<td>(2) smooth surface support</td>
<td></td>
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<tr>
<td>(3) roller</td>
<td></td>
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<tr>
<td>(4) ball and socket</td>
<td></td>
</tr>
<tr>
<td>(5) single journal bearing</td>
<td></td>
</tr>
<tr>
<td>(6) single journal bearing with square shaft</td>
<td></td>
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<tr>
<td>(7) single thrust bearing</td>
<td></td>
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<tr>
<td>(8) single smooth pin</td>
<td></td>
</tr>
<tr>
<td>(9) single hinge</td>
<td></td>
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<tr>
<td>(10) fixed support</td>
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</table>
single smooth pin

L15 - 3d reactions
Joint Connection

Welded connection

Gusset plate

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Calculate the reaction forces at the support

\[ \theta = \tan^{-1}\left( \frac{1.75}{6} \right) \]

\[ \theta = 16.26^\circ \]
Approach: ① Rigid support = 6 unknowns
② FBD & use 6 EoE
③ 6000 \(\Rightarrow\) -Z-direction only
④ 500 lb \(\Rightarrow\) 2-planes only