<table>
<thead>
<tr>
<th></th>
<th>Single Axis</th>
<th>Friction Brake</th>
<th>Polycentric</th>
<th>Hydraulic</th>
<th>Micro-Controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stability</strong></td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>Low</td>
<td>Low</td>
<td>Mid</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Gait Efficiency</strong></td>
<td>Poor</td>
<td>Poor</td>
<td>Mid</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Low</td>
<td>Low</td>
<td>Mid</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Image by MIT OpenCourseWare.

**Prosthetic Knee Joints:**
Cost/Performance Comparison
<table>
<thead>
<tr>
<th></th>
<th>Single Axis</th>
<th>Friction Brake</th>
<th>Polycentric</th>
<th>Hydraulic</th>
<th>Micro-Controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Cost</td>
<td>Low</td>
<td>Low</td>
<td>Mid</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Gait Efficiency</td>
<td>Poor</td>
<td>Poor</td>
<td>Mid</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Weight</td>
<td>Low</td>
<td>Low</td>
<td>Mid</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Image by MIT OpenCourseWare.

Prosthetic Knee Joints: Jaipur/Stanford Model
- Polycentric
- Good gait-efficiency
- Withstands 2 million cycles (~2 years)
- Affordable (<$30)

Stanford-Jaipur Knee: Current Model Benefits

Engineering drawing of Stanford-Jaipur Knee removed due to copyright restrictions.
Limitations of Stanford-Jaipur Knee

- Wide and bulky
- Noise (Click!)
- Shock / Discomfort

- Better manufacturing?
  - Requires milling or molding
  - Each site requires a mold

Photo of boy walking with Stanford-Jaipur Knee removed due to copyright restrictions.
• Revise the Stanford-Jaipur knee
  ◦ No milling, no molding
• Build a prototype at Fab Lab
  ◦ Also introduce small improvements
    (e.g. no bolts sticking out)
• Test our prototype

Our Project part 1
Engineering drawing of LegoLeg courtesy of Giovanni Talei Franzesi, Jacquelyn Kunkel, and Matthew Rodriguez. Used with permission.

Lego Foot
Waterjet Cutter

- Easy to use
- Fast
- Economical
- Can slice carbon-fiber sheets into various shapes
- No molds required
Waterjet Cutter

- Available at Fab Lab
- Omax 2652 can handle up to 26in x 52in
Test our prototype

- Is our modified Stanford-Jaipur knee as good as the original?

Images of MIT's Tim the Beaver and the Stanford Tree mascot have been removed due to copyright restrictions.
Fatigue test

- Apply adduction moment
  - \( \sim 3\% \times \text{bw} \times \text{ht} \)
  - \( =34.1 \text{ Nm} \)
- 2 million cycles

Image of the Stanford-Jaipur Knee undergoing a stress test has been removed due to copyright restrictions.
Fatigue test

- Apply adduction moment
  - \( \approx 3\% \times \text{bw} \times \text{ht} \)
  - \( = 34.1 \text{ Nm} \)
- 2 million cycles
Ultimate Strength Test

- Increase force at 20N/s (1Nm/s)
- Stanford knee failed at 3500N (175Nm)
Wear Test

- Wear from cyclical rotary motion within the knee joint bearing surfaces

Image of the Stanford-Jaipur Knee undergoing a wear test has been removed due to copyright restrictions.
Limitations of Stanford-Jaipur Knee

- Wide and bulky
- Noise (Click!)
- Shock / Discomfort

- Better manufacturing?
  - Requires milling or molding
  - Each site requires a mold
Limitations of Stanford-Jaipur Knee

- Wide and bulky
- Noise (Click!)
- Shock / Discomfort

Better manufacturing?
- Requires milling or molding
- Each site requires a mold
Our Project part 2: Dampers

- Viscous damping during swing phase
- Reduces impact
- Preserves joints
- Natural gait.
Pneumatic dampers

- More suitable for low cost knee designs than are hydraulic dampers
- Medium is environmental air
- Already incorporated
Engineering model of pneumatic device removed due to copyright restrictions.

- Pneumatic
- low cost
- long throw

Adam Dahl’s design
• Step 1: Redesign Stanford-Jaipur Knee
  ◦ No milling, no molding
- Step 1: Redesign Stanford-Jaipur Knee
  - No milling, no molding
- Step 2: Build a prototype @Fab Lab & test
• Step 1: Redesign Stanford-Jaipur Knee
  ◦ No milling, no molding
• Step 2: Build a prototype @Fab Lab & test
• Step 3: Build a pneumatic damper
• Step 1: Redesign Stanford-Jaipur Knee
  ◦ No milling, no molding
• Step 2: Build a prototype @Fab Lab & test
• Step 3: Build a pneumatic damper
• Step 4: Introduce damper into the knee

Summary
- Step 1: Redesign Stanford-Jaipur Knee
  - No milling, no molding
- Step 2: Build a prototype @Fab Lab & test
- Step 3: Build a pneumatic damper
- Step 4: Introduce damper into the knee
- Step 5: Optimize the damper

**Summary**
• Step 1: Redesign Stanford-Jaipur Knee
  ◦ No milling, no molding
• Step 2: Build a prototype @Fab Lab & test
• Step 3: Build a pneumatic damper
• Step 4: Introduce damper into the knee
• Step 5: Optimize the damper
1~3 weeks per step

Summary
- Step 1: Redesign Stanford-Jaipur Knee
  - No milling, no molding
- Step 2: Build a prototype @Fab Lab & test
- Step 3: Build a pneumatic damper
- Step 4: Introduce damper into the knee
- Step 5: Optimize the damper

1~3 weeks per step
We have 7 weeks after spring break

**Summary**
• David – research on pneumatic dampers
• Amber – modify design so that it can be waterjetted
• Ryu – incorporate improvements Dr. Pooja suggested