ME Team 68
Design of an Articulating Ankle for Enhanced Performance

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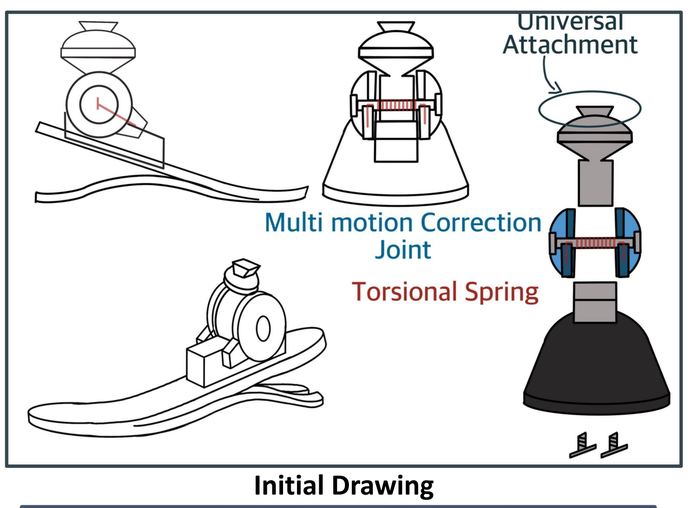
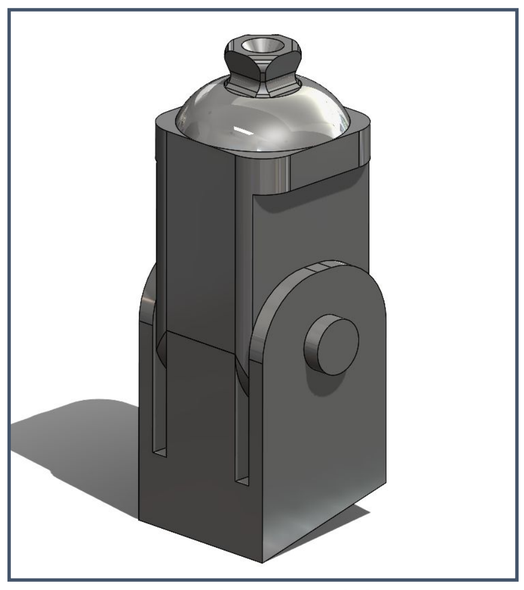
Design 2: Torsional Spring

- **Design Components:**
  - **Max Torque Range:** 250 - 650 N*mm
    - 258.74, 268.93, 383.02, 508.43, 623.45
  - **Pin:** 10.5 mm diameter
- **Initial Concerns:**
  - Overextension
    - Solution - Add pin to limit range of motion

Attractions:
- Most sleek & compact design
- Generates a lot of torque to help with recovery stroke



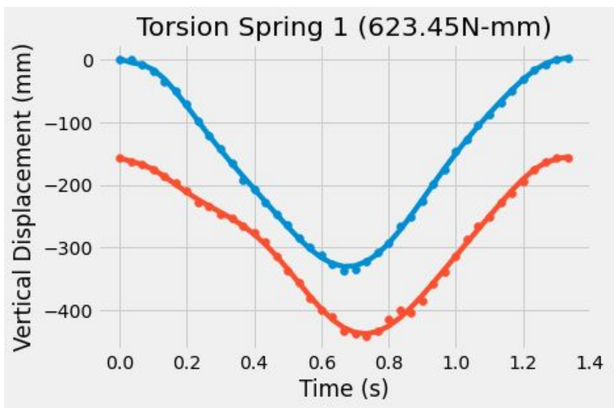
Initial Drawing



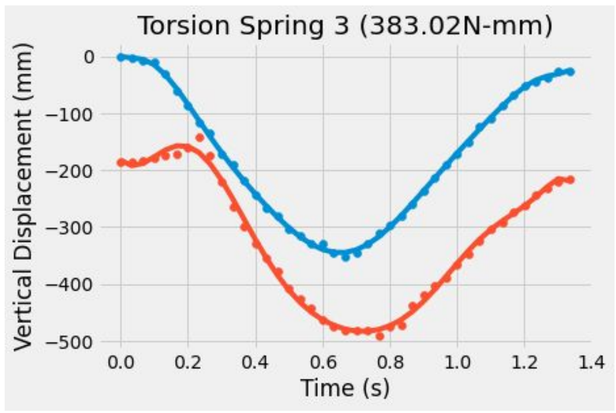
Initial CAD Model

Final Design

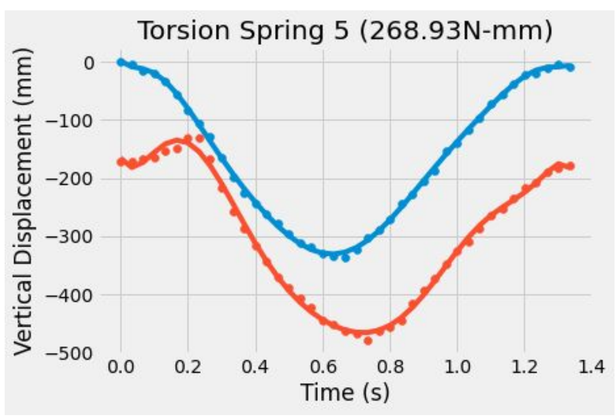
Results & Analysis Design 2



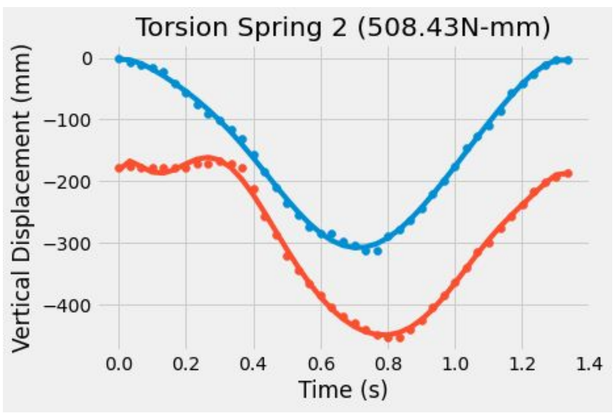
- Satisfactory recovery
  - Slightly thicker peak
- Good downstroke
  - Almost full extension of ankle



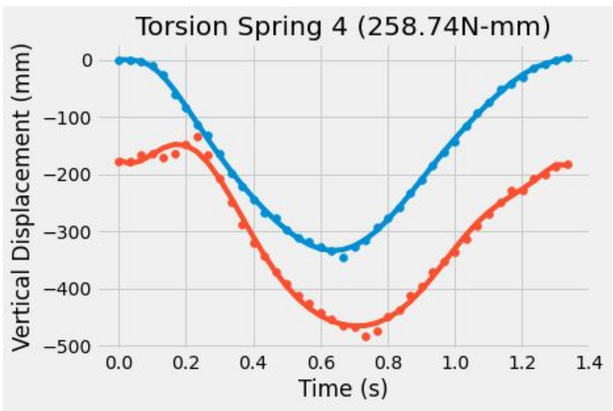
- Weaker recovery
  - Thicker peak
- Stronger Downstroke
  - Full extension of ankle



- Strongest recovery
  - Narrowest peak
- Weakest downstroke
  - Ankle not fully extended



- Less powerful recovery
  - Thicker peak
- Strong Downstroke
  - Full extension of ankle

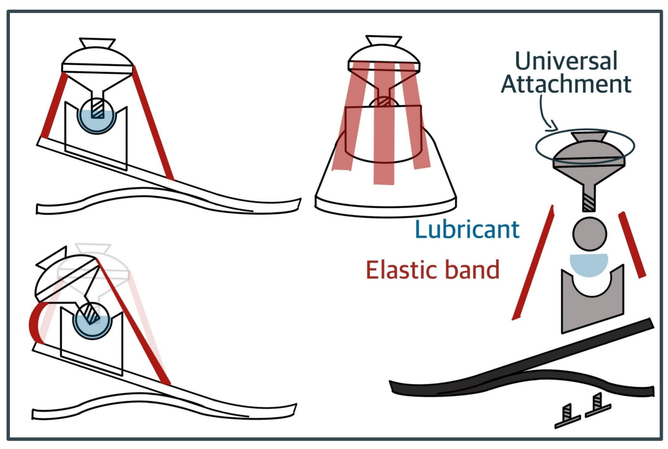


- Weakest recovery
  - Thickest peak
- Strongest Downstroke
  - Full extension of ankle
  - Closest path to ankle range of motion

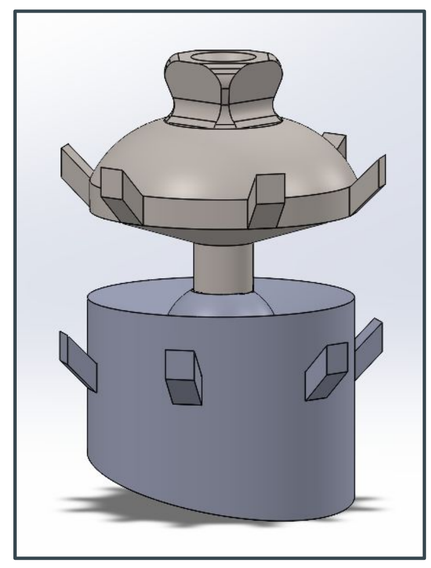
Design 3: Ball & Joint

- **Design Components:**
  - **Lubricant:** Oil or putty based
  - **Elastic Band:** 50.8 mm
- **Initial Concerns:**
  - Lubrication Dissipation
    - Solution - Use of putty lubricant

Attractions:
- Most human like
- Larger range of motion

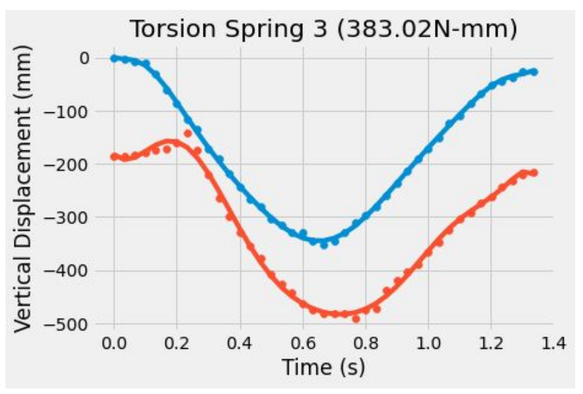


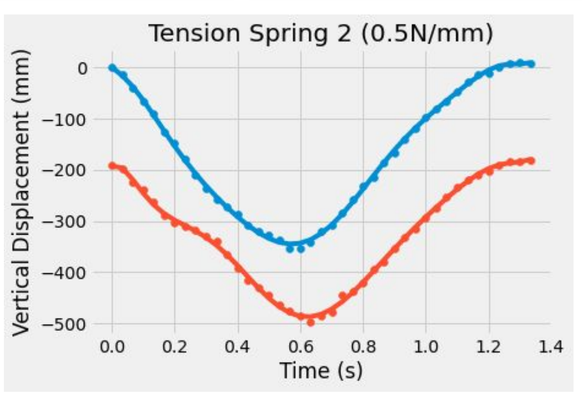
Initial Drawing



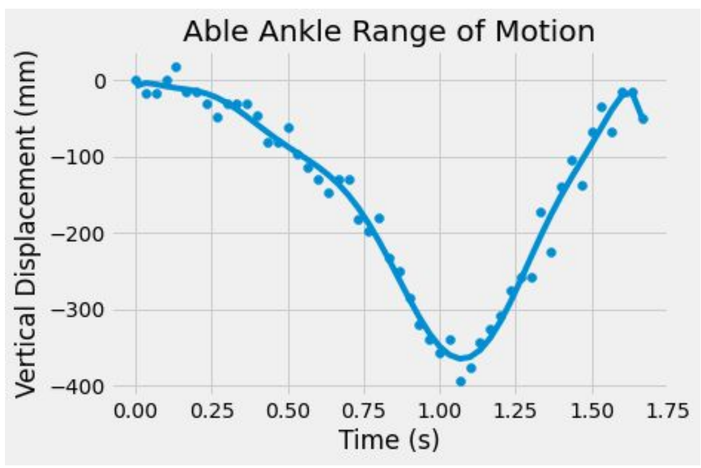
Initial CAD Model

Design Comparison & Final Design





- Tension spring iteration 2 and torsion spring iteration 3 had the best balance of their respective springs
- Torsion design had a stronger downstroke with a fully extended ankle while tension design had a better recovery



- Able ankle has longer downstroke and shorter upstroke because of required energy and drag
- Could not simulate because powerful motor generated constant oscillation & no flipper use in test rig testing

- Torsional spring design has a more similar downstroke while tension spring design has a more similar upstroke
- Both have same recovery angle as able foot

Conclusions & Recommendations

- **Conclusions**
  - Torsion spring 3 performed best with ankle range of motion
  - Tension spring 2 produced the most balanced stroke out of design 1 & torsional spring 3 produced the most balanced stroke out of design 2
    - Torsional spring 3 performed better in terms of downstroke
    - Tension spring 2 performed better in terms of recovery stroke
  - Flipper deflection was inconclusive
    - Require a larger tank with slower arm oscillation
  - Can create a design that doesn't require position adjustments
- **Recommendations**
  - Complete Human Testing
    - Focus on quantitative & qualitative metrics
      - Flipper Deflection & ankle range of motion
      - SWOLF, pace, heart rate, & comfortability
  - Pursue finding "ideal" spring constant for tension spring design
  - Fabricate and test Ball & Joint Design

Acknowledgements

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References

1. "Activankle & Swimankle, Prosthetic Ankle Joints for Swimming, Jet/Snow Skiing, Rowing." Rampro, https://www.rampro.net/ .
2. "Journal of Biomechanical Science and Engineering." Development of the Transfemoral Prosthesis for Swimming Focused on Ankle Joint Motion, vol. 8, no. 1, 2013, p. 93. Journal of Biomechanical Science and Engineering, https://www.jstage.jst.go.jp/article/jbse/8/1/8_79/_pdf.