DEPARTMENT OF MECHANICAL ENGINEERING

ME Team 8
Tendon Tappers

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Problem Definition

Many veterans and elderly **suffer** from chronic back pain

Going to and from the hospital for **routine check ups** can be **burdensome**

Doctors want to examine patients' reflexes **remotely** through telemedicine

Objective: Create a self-performing Deep Tendon Reflex hammer for remote patients.

Design Calculations & Analysis

Motor Selection

Using an accelerometer to measure α of DTR test, the team was able to calculate required Torque

RPM				
Trial	Ethan	Miles	Sam	Peter
1	20.52672001	7.505089495	26.7264674	14.12214021
2	15.84860536	7.502545563	22.77735563	12.91984552
3	17.52163264	8.04198535	20.82188878	16.3689561
4	17.23537337	11.00636693	28.50000104	17.99364484
5	19.62086415	7.5763368	12.98473299	17.93129748
Averages:	18.15063911	8.326464828	22.36208917	15.86717683
Standard Dev:	1.893412399	1.514842922	6.066325738	2.278494975

ω_0=0 RPM, ω_{max}=22 RPM

$\Delta\theta=45^o$, $\alpha=3.379\ rad/s^2$

$T_{req}=I\alpha+g(\sum m_i L_i)=4.0653\ N\cdot cm$

Metal Support Thickness

Weights:

$W_M=1.08$ N, $W_B=0.981$ N, $W_S=0.676$ N

Via Force and Moment Calcs:

$R_{Ay}=1.991$ N, $R_{Cy}=1.717$ N

$R_A=2.9188$ N, $R_C=2.5169$ N

$R_B=2.1298$ N, $R_D=1.8365$ N

$A_{min}=R_A/\sigma=1.058\cdot10^{-8}\ mm^2$

Internal Forces

$N=1.9958$ N, $V_y=2.129$ N, $V_z=0$ N

$T=0\ N\cdot m$, $M_y=0\ N\cdot m$, $M_z=0.07774\ N\cdot m$

Stresses and Mohr's Circle

$\sigma_{xx}=79.83/t$ Pa, $\tau_{max}=127.8/t$ Pa, $\sigma_{Mz}=0.466/t^3$ Pa

$C=(39.9/t, 0)$, $Pt=(79.8/t, 127.8/t)$, $R=133.87/t$

$\sigma_1=173.8/t$ Pa, $\sigma_3=-93.66/t$ Pa, $S_{ys}=138\cdot10^6$ Pa

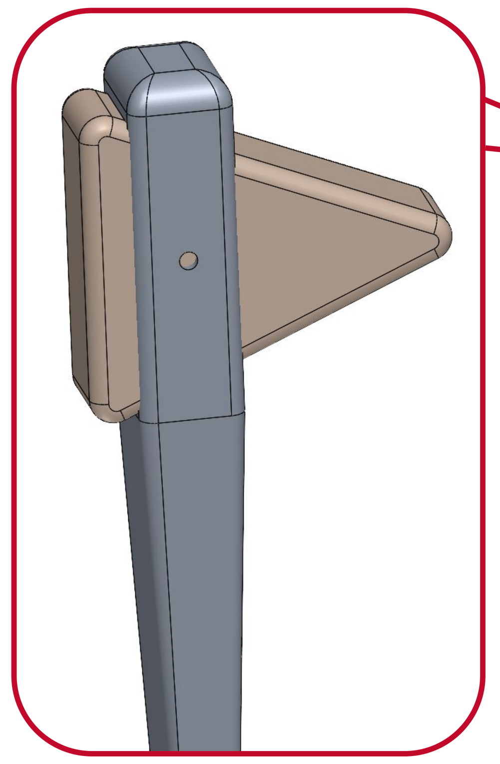
$\tau_{max}=133.87/t$ Pa

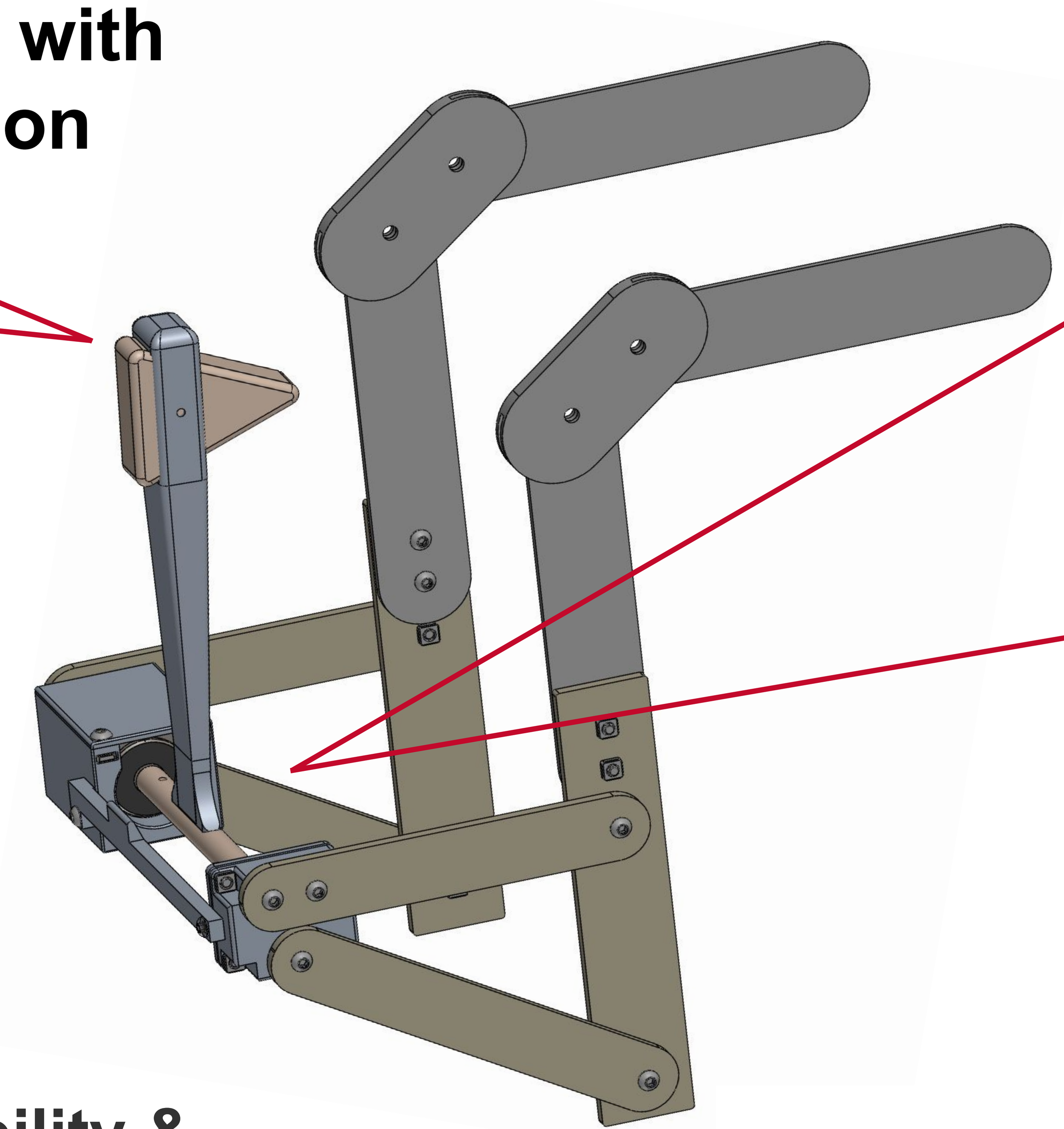
$\sigma_{xxmax}=\sigma_{xx}+\sigma_{Mz}=2S_{ys}$

$t_{min}=1.19$ mm, $t=3$ mm

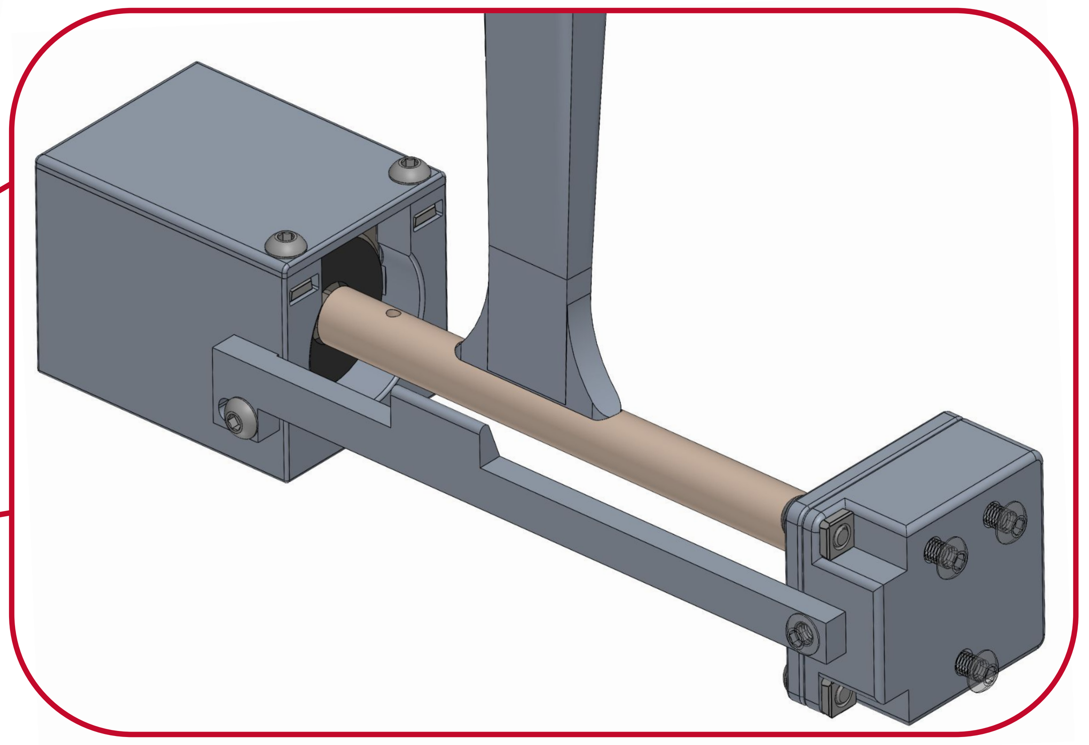
Final Design

Device Interface with Patient's Tendon





Actuation



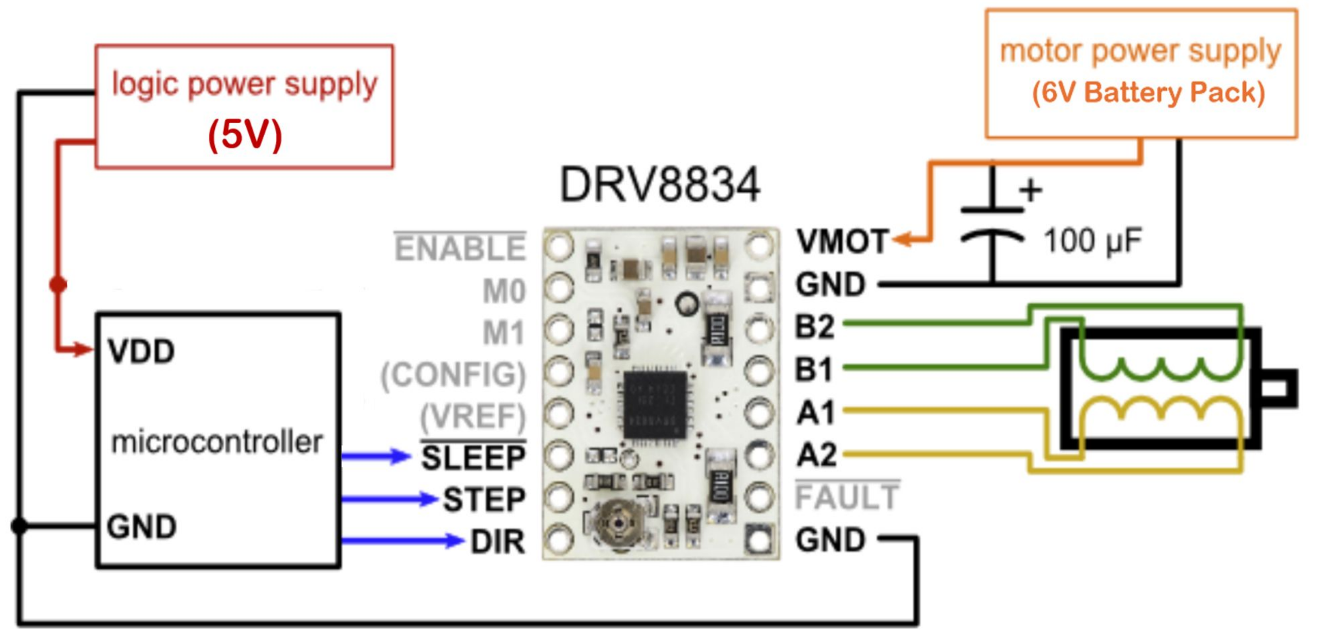
Design Decisions:

- 8mm stainless steel shaft, interfaced with plastic hammer.
- 3.8V Stepper Motor.
- 8mm ID Plastic Ball Bearing.
- Atom Matrix for IMU sensor and button.
- 3mm fasteners to improve sustainable design for modularity.

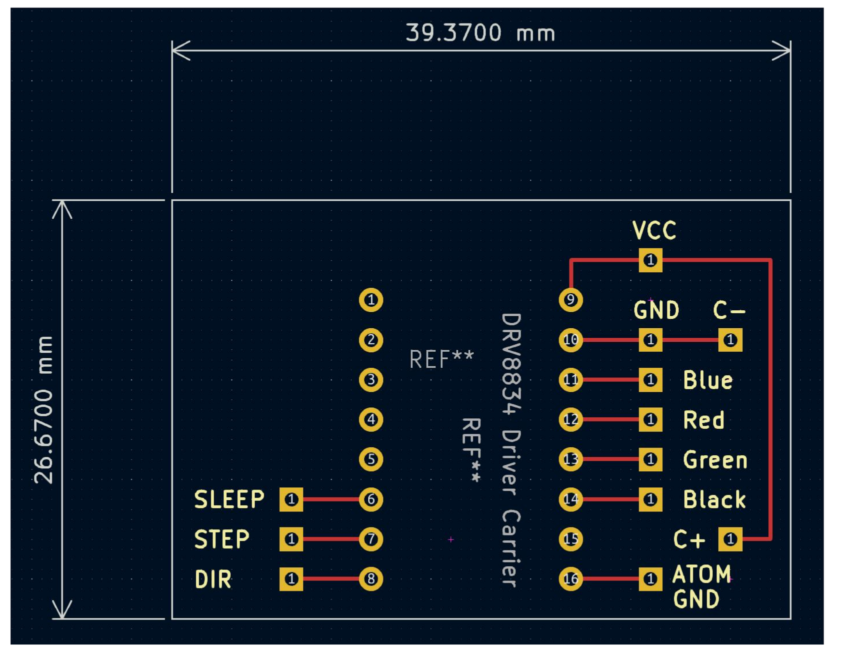
Patient Adjustability & Material Selection

- The design is integrated into an adjustable hinged knee brace (comes in different standard sizes, depending on the patient's knee size).
- High-strength thermoplastic material hammer tip.

Electronics



Circuit Wiring Diagram [1]



PCB Wiring Diagram

[1] Diagram adapted from Pololu DRV8834Low-VoltageStepper Motor Driver Carrier

Prototype & Test Results

Drop Test

Goal: Ensure that the brace can survive a drop of three feet.

Procedure:

1. Set up the device where 6 faces are parallel to the ground.
2. Hold the device 3 feet above the ground.
3. Drop the device.
4. Perform visual inspection on the device and confirm motor runs.
5. Repeat all steps a second time in all orientations.

Conclusion: The device can survive a drop of three feet.

Motor Test

Goal: Ensure a PLA shaft can support the torque of the motor

Procedure:

1. Fully assemble the prototype
2. Let the motor pulse between its starting position and the striking point at 300 RPM. A cycle consists of the shaft starting at the base, rotating to the striking point, and rotating back to the base.
3. Run the motor for 30 cycles.

Conclusion: A plastic shaft cannot support the required torque. A stronger shaft is needed.