

# Midterm project. KIAN HAGEMAN twitch / tremor dampers

## Deliverables

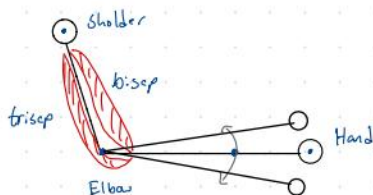
- I. Mathematical model and bio mechanics
- II. Solid model and Virtual prototype
- III. Design Specifications
- IV. Low fi Proto type
- V. Standard Operating Procedure
- VI. Presentation

- I. Mathematical model and bio mechanics

Need to model { Lower Arm  
Tremors  
Dampner

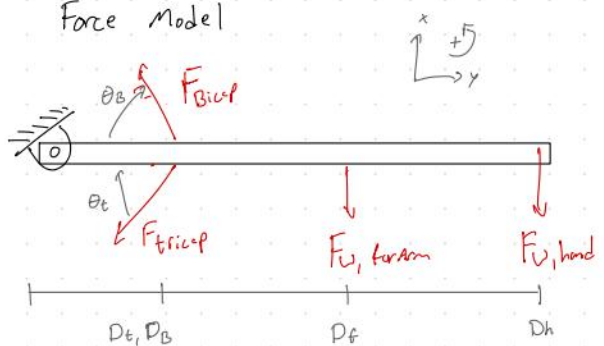
- tremors are, in this model, caused by the activation of Bicep and tricep muscles.
- See model below for initial arm biomechanics

## Lower Arm Model



Bicep and tricep control for arm motion in plane.

## Force Model

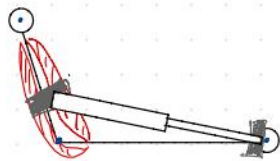


- Argument for no gravity in model. The muscles are always active as to counter gravity, such that the only meaningful forces are those caused by the additional twitching.
- No-Gravity point: Because the device is attached to the hand, the device does not need to counter gravity, nor can it. See graphic below.

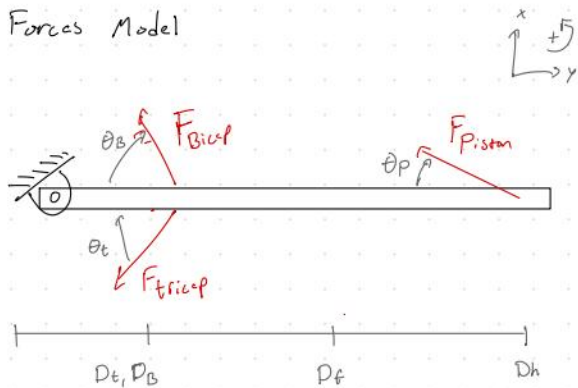
- Old fix. upper arm to wrist passive piston stability

Biomechanics model

Forces Model



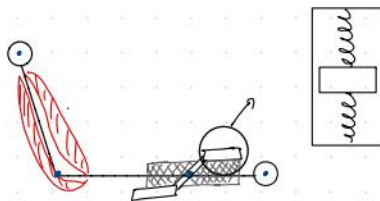
- fixed pneumatic piston.
- Bulky - heavy
- Hard to maneuver



- new fix

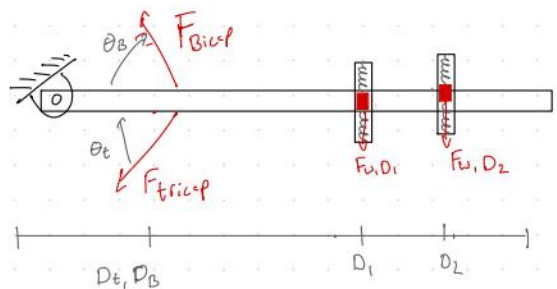
Biomechanics model

Spring Damp System



- Only on forearm
- Easy to put on yourself
- Small and light weight

Forces model



- Need to use a dynamic model, static model does not make sense as it needs movement to activate

- Springs move such that when a twitch instantly happens the position of the weight does not change, thus counter acting the twitch force

- Oscillation out of phase of tension.

## - Modeling tremors

- After some research a tremor can be modeled as a Sinoid function

$$F_{\text{tremor}} = A \sin(\omega t + \phi) + B \rightarrow \text{pratically modeled as } F_{\text{tremor}} = A \sin(\omega t)$$

- We can use a differential EQ used for mechanical force dampers.

$$F_t = Mx'' + Cx' + kx \rightarrow \text{pratically modeled as } F_t(t) = M_t x''(t)$$

## - Modeling our damping force

- Given  $F_t(t) = M_t x''(t)$  our total damping force in an ideal system must be equal

- we are using a mechanical damping model

two systems are accounted for, the arm and the Damper

$$\text{Arm} \rightarrow F_{\text{damp}} = M_p x_p'' + C_p x_p' + k_p x_p \quad \text{but} \quad \begin{array}{l} C = 0 \\ k = \text{Body stuff?} \end{array}$$

$$0 = M_p x_p'' + k_p x_p' + F_{\text{damp}}$$

$$\text{Damper} \rightarrow 0 = M_d x'' + C_d x' + kx$$

$$x' = x_d' - x_p' \quad \text{and} \quad x = x_d - x_p$$

$$0 = M_d x_d'' + C_d (x_d' - x_p') + k_d (x_d - x_p)$$

$x_d$  = displacement of device weight

$C_d (x_d' - x_p')$  = damping force

$k_d (x_d - x_p)$  = Spring force

- Knowing these two are equal

$$x_p'' = -\omega^2 A \sin(\omega t) \rightarrow \text{Such that } F_t(t) = -M_t \omega^2 \sin(\omega t)$$

- Solving for Damping force

$$F_{\text{tremor}} = -F_{\text{Damping}}$$

$$m_p x_p'' = c_d (x_d' - x_p') + k_d (x_d - x_p)$$

- Assuming Steady-State harmonic motion

$$\begin{array}{ll} x_p = A_p e^{j\omega t} & x_d = A_d e^{j\omega t} \\ x_p' = j\omega x_p & x_d' = j\omega x_d \\ x_p'' = -\omega^2 x_p & x_d'' = -\omega^2 x_d \end{array} \left. \vphantom{\begin{array}{ll} x_p = A_p e^{j\omega t} & x_d = A_d e^{j\omega t} \\ x_p' = j\omega x_p & x_d' = j\omega x_d \\ x_p'' = -\omega^2 x_p & x_d'' = -\omega^2 x_d \end{array}} \right\} \begin{array}{l} \text{Sub into equation above} \\ \text{and simplify} \end{array}$$

$$F_d = -c_d j\omega (x_d - x_p) - k_p (x_d - x_p)$$

- For ideal tremor reduction so  $m_d$  is such that  $\omega_d = \omega_t$
- $k_d$  is selected to tune to dampers natural frequency

$$\omega_d = \sqrt{\frac{k_d}{m_d}}$$

- instead of manually calculating values, I had chat GPT help write a matlab code to model
- Solving for mass of damper

$$m_d = \frac{k_d}{\omega_t^2}$$

- Creo model

prototype  $\rightarrow$  2x Sleeves

2 different weights

Sizing guidelines  $\rightarrow$  Based off of myself (6'5") or 77" tall  
and realistic guesses.

- Calculating Spring Sizes

$$\text{Box} = 2.50 \text{ in} - 2 \times 0.05 \text{ in} = 0.24$$

$$\text{Lead} = 0.50 \text{ in}$$

$$\text{Box Spring room} = 2.4 - 0.5 = 1.9 \text{ in}$$

$$\text{Spring} = \frac{1}{2}(1.9 \text{ in}) = 0.95 \text{ in height / Length}$$

Spring width 0.8 in max

going to use 1 in height \* 0.75 in width max

using table 3.2 from Slides "Lecture 3"

Height  $\rightarrow$  hand size  $\rightarrow$  1/10

$$\text{Bicep circumference} = 0.17$$

$$\text{Arm} \rightarrow = 0.40$$

$$\text{piston} : 0.2H \text{ for both F/M}$$

$$\text{KIAN Height} = 77 \text{ in}$$

consumables vs equipment.

# Matlab model notes.

- User input variables : all determined by research.

Some specifically interesting ones

- Human damping coefficients are governed by  $C = 2 \zeta \sqrt{mk}$
- Human Stiffness coefficients where acquired from studies
- Non-human Stiffness : designed to match resonant frequency
- Weights were based off of standard tables.

- I used chat GPT to help implement and trouble shoot programming problems.
- I also used it to go behind my initial equations adding an element of randomness and smoothness
- Final model abilities

- i. models tremors
- ii. models Damping System
- iii. introduces variability in tremors
- iv. uses ODE 4S to solve equations
- v. easy to change model parameters

## vi. Advantages

- Tremors are random in Amp and freq, but are smooth.
- Tremors are customizable
- Good visual representation of all components
- Provides an easier understanding of the problems and Sol

## vii. Disadvantages

- I don't know to what degree the model is accurate in Speed to real tremors, probably over simplified
- Lack of muscle feedback
- Does not simulate any other body function that stops tremors, like CNS