High Cycle Fatigue of Electroactive Membranes

Team 20:
Nicholas Dawkins
Matthew Drys
Kristina Dukes
Adriane Guettler
Victor Odewale

Advisor: Dr. Oates
Sponsors: Dr. Clark and Dr. Oates
Instructors: Dr. Gupta and Dr. Helzer

Project Scope

Need Statement: There is a lack of information on the fatigue of electroactive membranes.

- Electroactive membranes are being studied for application onto robots.
- There is insufficient data on the fatigue behavior for electroactive membranes [1]
- The purpose of this project is the design and implementation of a fatigue mechanism for electroactive membranes

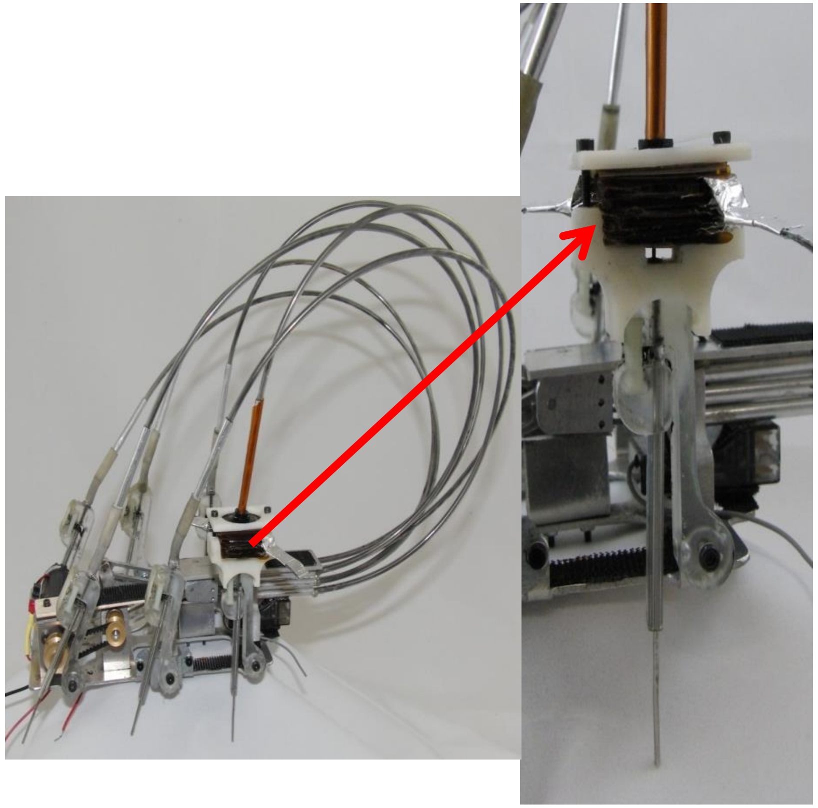

Figure 1. iSprawl Robot with VHB membrane stack[2]

[1] Oates, William and Jonathan Clark. "High Cycle Fatigue of Electroactive Membranes." Florida A&M/Florida State University, 2014. Print.
[2] Newton, Jason. "Design And Characterization Of A Dielectric Elastomer Based Variable Stiffness Mechanism For Implementation Onto A Dynamic Running Robot." Thesis. Florida State University - College Of Engineering, 2014. Print

Adriane Guettler

Project Scope

Goal Statement: Design and build a device that produces high cycle sinusoidal mechanical fatigue of electroactive membranes.

Objectives:

- Accurately measure the fatigue placed on the specimen
- Produce various frequencies of cycling
- Produce varying stroke distances to displace the membrane
- Allow for tracking of the displacements controlled by the fatigue machine
- Measure the load associated with the stroke by implementing with the MTS machine

Adriane Guettler

Project Scope

Constraints

- System should be a tabletop mechanism that is mounted to the MTS machine
- Vary stroke from 0 to 10mm
- Vary frequency from 0 to 25 Hz
- Produce consistent functionality for various specimens
- Test 1 to 5 specimens at a time
- Complete within the budget

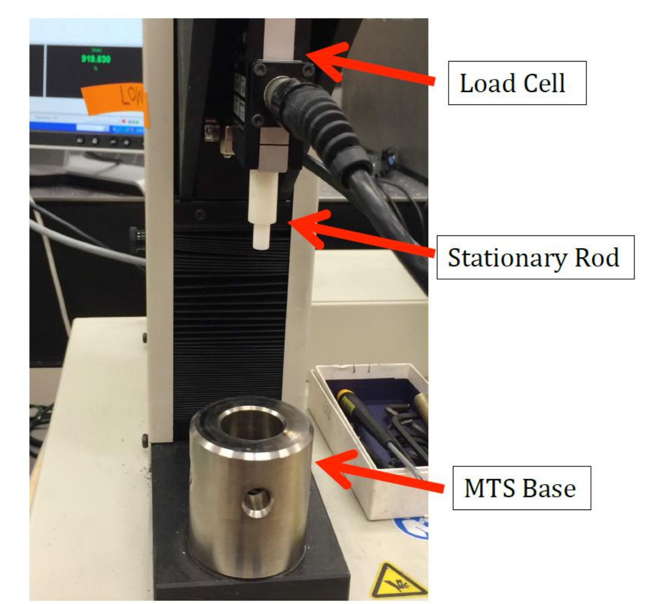

Figure 2. MTS machine

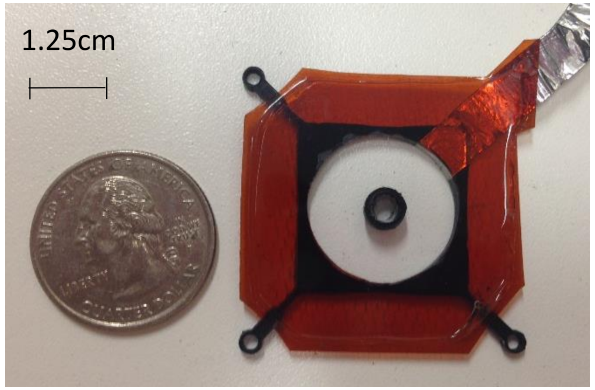

Figure 3. VHB membrane specimen

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Midterm 2

Dynamic Force Analysis

<u>Most Extreme Conditions</u>

Displacement x = 10mm

Frequency f = 25 Hz

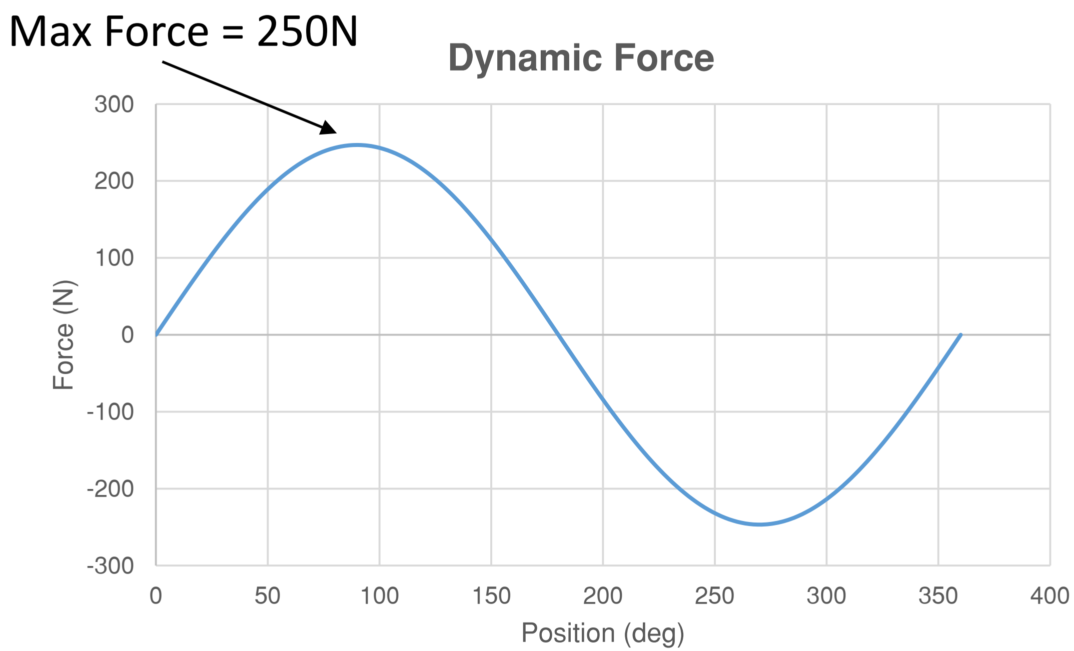
Displacement: $x = x_o \sin(\omega t)$

Acceleration: $\ddot{x} = x_o \omega^2 \sin(\omega t)$

Total Force: $F = m * a = m * \ddot{x}$

Factor of Safety = 2

Max. Allowable Force = 500N



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Design - Platform

- Platform to secure and test up to 5 specimens

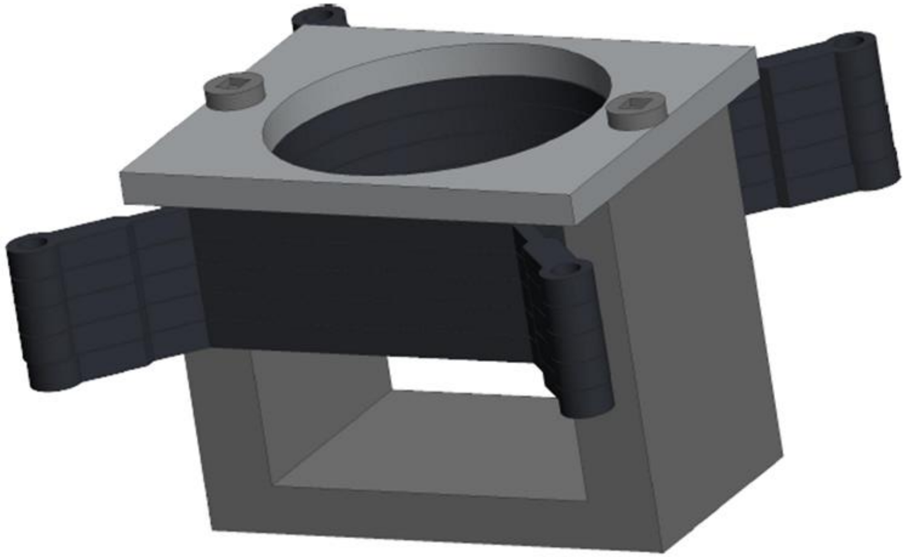

Figure 4 (a) Platform rendering

All dimensions are in millimeters

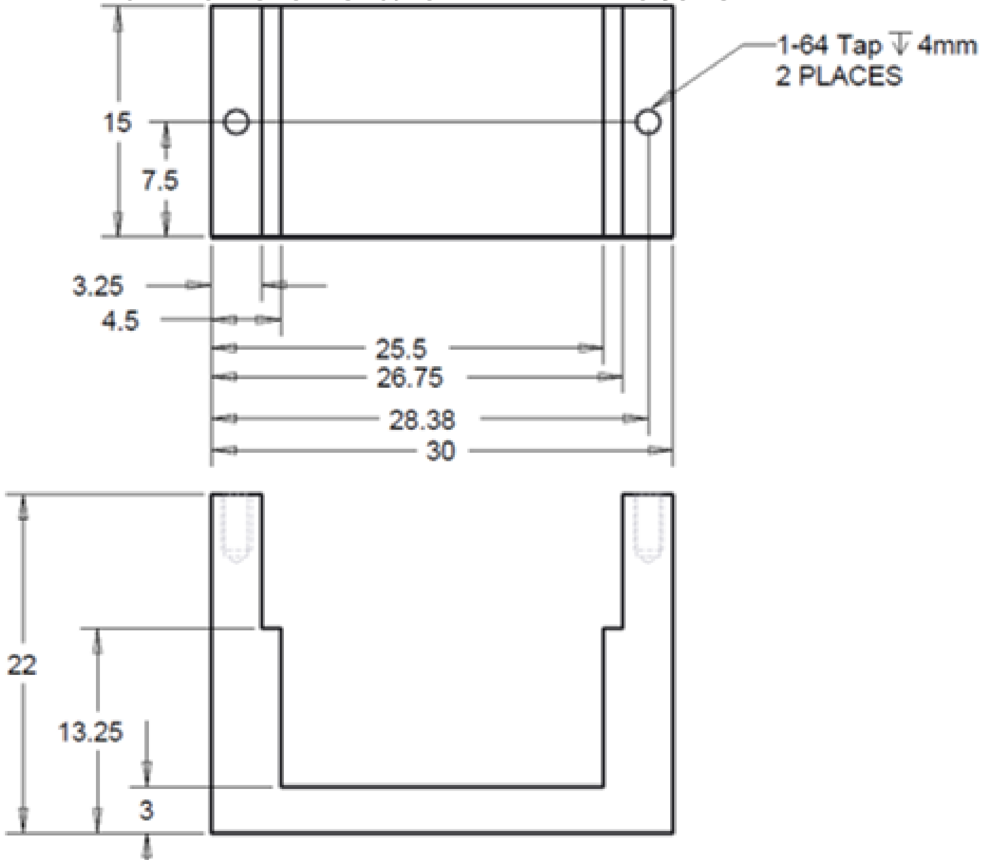

Figure 4 (b) Platform drawing

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Designs

Three designs selected for concept of operation

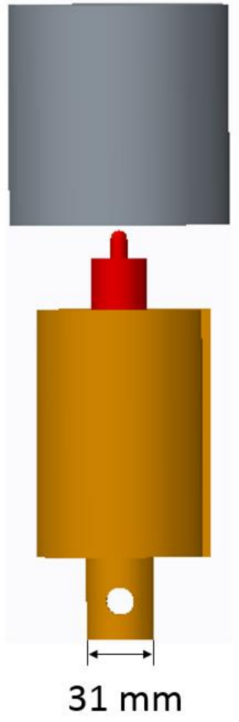


Figure 5. Solenoid Design

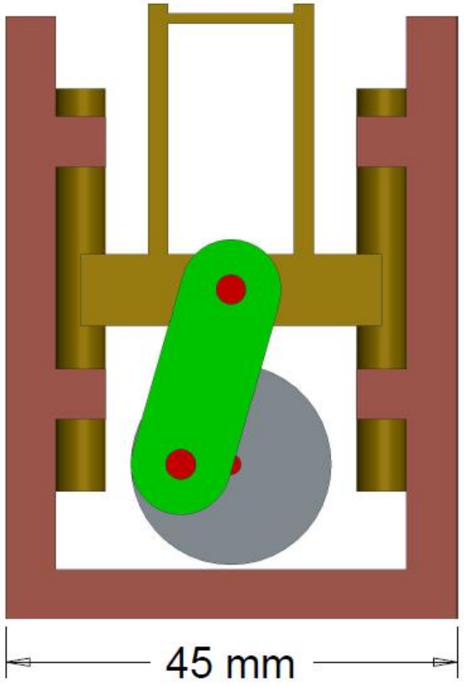


Figure 6. Crank Slider Design

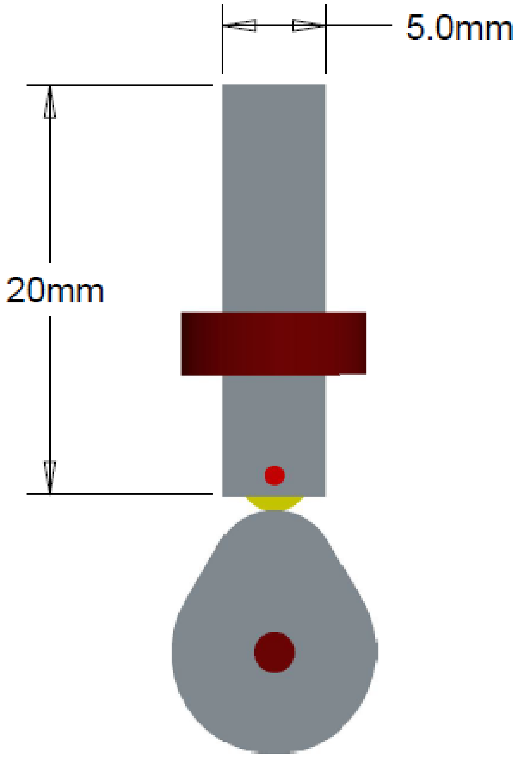


Figure 7. Cam Design

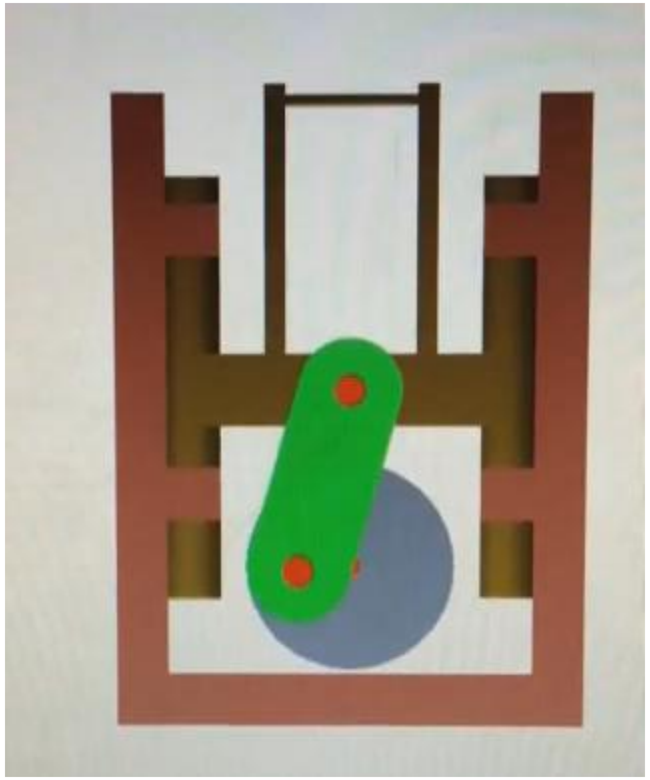
Design Selection

Decision Matrix

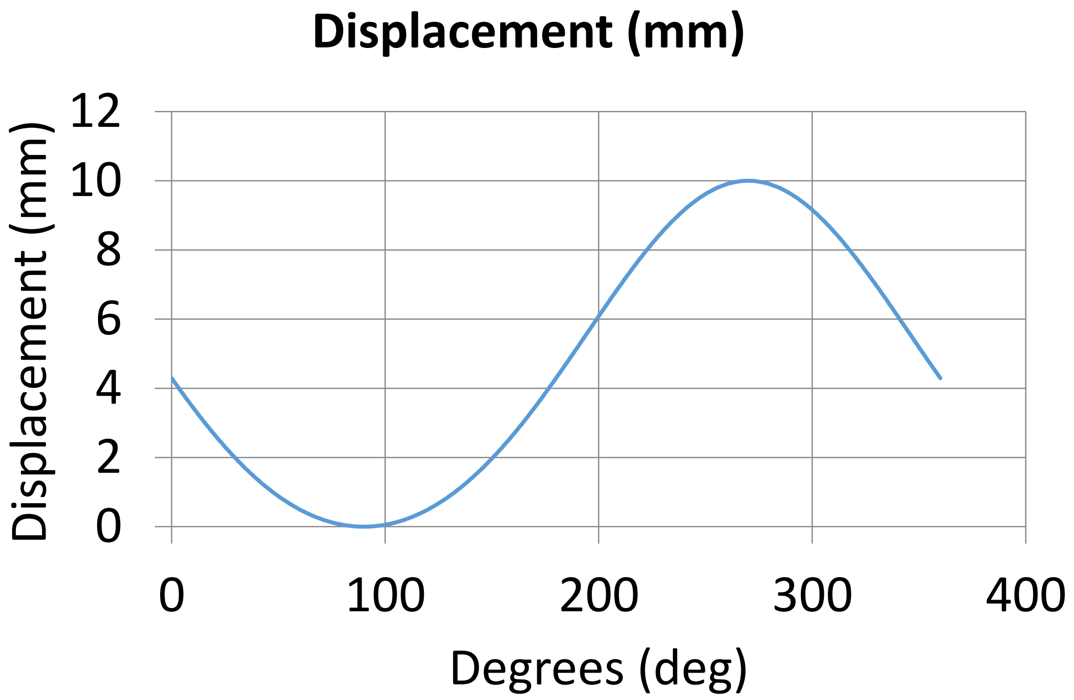
- Ranking Scale
  - 1-poor, 3-adequate, 5-best

Team 20 Design Decision Matrix						
Design	**Safety**	**Low Cost**	**Ease of Use**	**Reliability**	**Performance (vary stroke & frequency)**	**Total**
	0.20	**0.05**	**0.10**	**0.20**	**0.45**	
Solenoid	5	5	5	3	3	**3.7**
Crank Slider	3	3	3	5	5	**4.3**
Cam	3	3	1	5	5	**4.1**

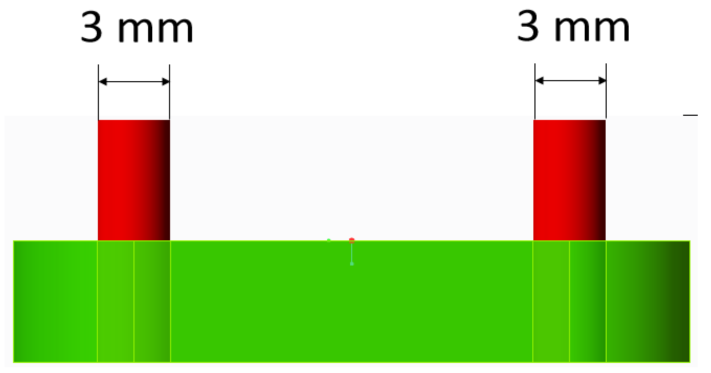
Modeling and Analysis



Stroke Throughout Cycle



Modeling and Analysis



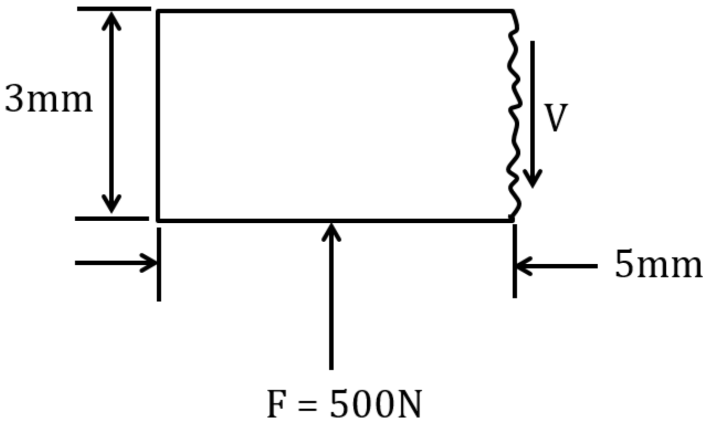


Figure 8 (a) Linkage and pins (b) FBD of pin.

Pin Reactions

Shear Force

$$\Sigma F_y = F - V = 0$$

$$V = F = 500N$$

Shear Stress

$$\tau = \frac{V}{A_c} = \frac{V}{\pi r^2}$$

$$\boxed{\tau = 70.7MPa}$$

Possible Pin Material: Stainless Steel

$$\sigma_y = 170 - 1000\ MPa$$

Matthew Drys
Midterm 2

Modeling and Analysis

Motor Calculations

Most Extreme Conditions

Displacement x = 10mm

radius = 5mm

Frequency f = 25 Hz

Max. Allowable Force = 500N

Minimum Required Torque

$$Torque = F_{max} \cdot r = 500N \cdot 5mm$$

$$\boxed{Torque = 2.50\ N \cdot m}$$

Minimum Required Angular Velocity

$$\omega = \ 2\pi \cdot f = 2\pi \cdot 25Hz \ \cdot \frac{60s}{1\ min} \cdot \frac{1\ rev}{2\pi}$$

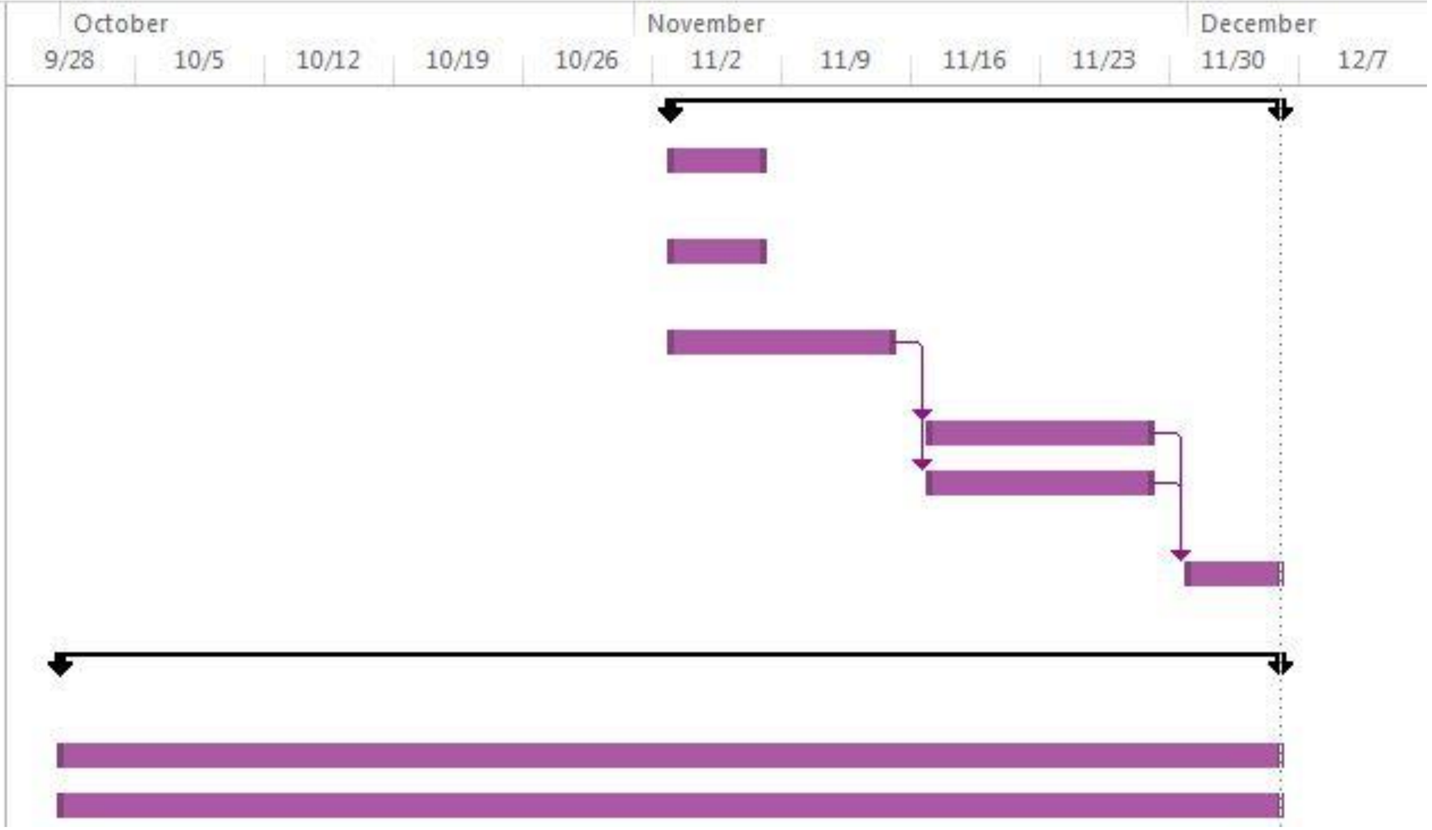
$$\boxed{\omega = 1500\ rpm}$$

Potential Challenges & Solutions

- Development of user interface
  - LabView
- Time syncing data from mechanism to MTS data
  - DAQ system
- Being a usable system on or off the MTS
  - Design base to accommodate
- Securing and testing multiple membranes
  - Variable mounting clamp

Schedule

Task Name	Start	Finish
Analysis of Machine	**Mon 11/3/14**	**Fri 12/5/14**
Force Analysis using CAD Assembly	Mon 11/3/14	Fri 11/7/14
Fatigue Analysis using CAD Assembly	Mon 11/3/14	Fri 11/7/14
Frequency to Velocity Analysis	Mon 11/3/14	Fri 11/14/14
Material Selection	Mon 11/17/14	Fri 11/28/14
Outsorcing of Motor and Power Source	Mon 11/17/14	Fri 11/28/14
Analysis of Cost Feasibility	Mon 12/1/14	Fri 12/5/14
Developing a User Interface	**Wed 10/1/14**	**Fri 12/5/14**
Sycronize with Lab View	Wed 10/1/14	Fri 12/5/14
GUI	Wed 10/1/14	Fri 12/5/14



Future Work

- Finalize CAD drawings and renderings
  - Housing
  - Guide rails
  - Mounting mechanism
  - Motor coupling
  - Slotted disk
- Select materials for mechanism
- Complete a cost analysis on the system
- Purchase motor and controller
- Design a working user interface

Summary

Need Statement: There is a lack of information on the fatigue of electroactive membranes.

Goal Statement: Design and build a device that produces high cycle sinusoidal mechanical fatigue of electroactive membranes.

- Vary frequency
- Vary stroke

Final Design Selected: Crank Slider mechanism

Key Next Step: Finalize design components

References

[1] Oates, William and Jonathan Clark. “High Cycle Fatigue of Electroactive Membranes.” Florida A&M/Florida State University, 2014. Print.

[2] Newton, Jason. "Design And Characterization Of A Dielectric Elastomer Based Variable Stiffness Mechanism For Implementation Onto A Dynamic Running Robot." Thesis. Florida State University - College Of Engineering, 2014. Print

Questions?

For more information visit our website:
www.eng.fsu.edu/me/senior_design/2015/team20/