Shear Stress Sensor

Group Members
Matthew Carmichael
Tyler Elsey
Luiz Paes

Sponsors
Dr. Dickinson , Eglin AFRL
Dr. Oates, FAMU & FSU College of Engineering

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OVERVIEW

- Project Scope, Objectives, and Constraints
- Existing Technology
- Technical Approach
- Final Design
  - Programming Needed
  - Parts Needed
- Schedule

Need Statement & Project Scope

- Need Statement
  - Need in the market for a shear stress sensor that can used outside the lab and decouple shear and normal stress
- Project Scope
  - Create Testing Apparatus
  - Determine if cholesteric crystals are able to measure shear stress

Objectives

- Create a testing apparatus using given baseplate and testing procedure
- Test Liquid Cholesteric Crystals
  - Possible to decouple the pressure and shear stress?
  - Determine the range of forces that can be detected
  - Determine how temperature affects the crystals
- Repeat tests with a polymerized form of cholesteric crystals

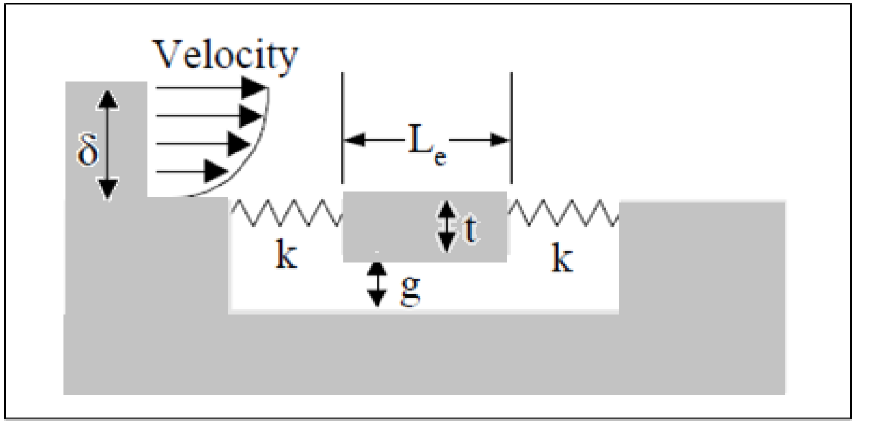
Constraints

- Baseplate and testing procedure have been created by a previous group
- Light wavelength sensor must be adjustable
- Stationary white light source with wide wavelength distribution.
- Cholesteric crystals must be able to be heated when needed

Existing Technology

Microelectricalmechanical Systems (MEMS)

Devices that have been fabricated using silicon micromachining technology

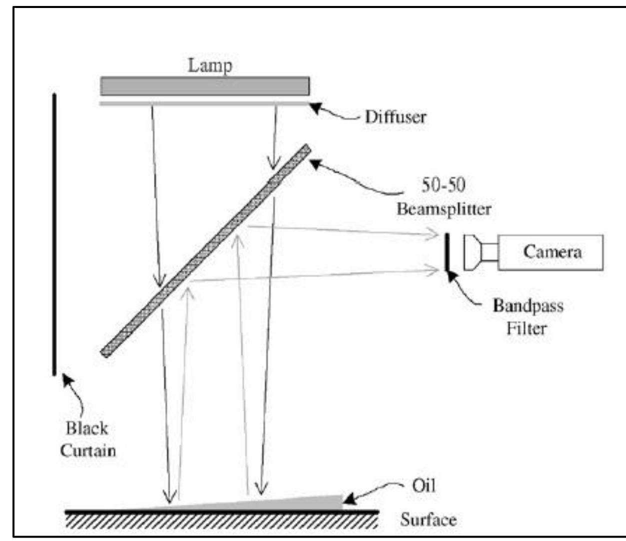


- **Pros**
  - **High Resolution**
- **Cons**
  - **Dirt can get trapped in sensor gaps**

Existing Technology

Thin-Oil Film

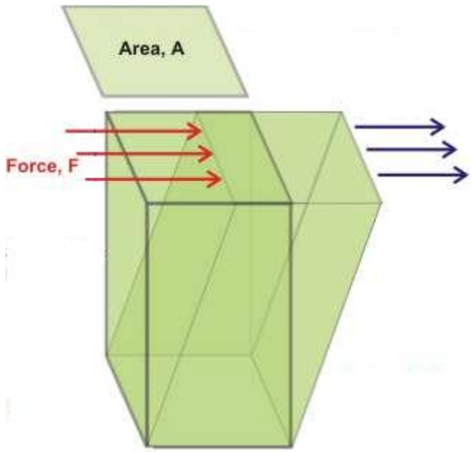
Oil thickness is measured via interferometry function of the local friction.

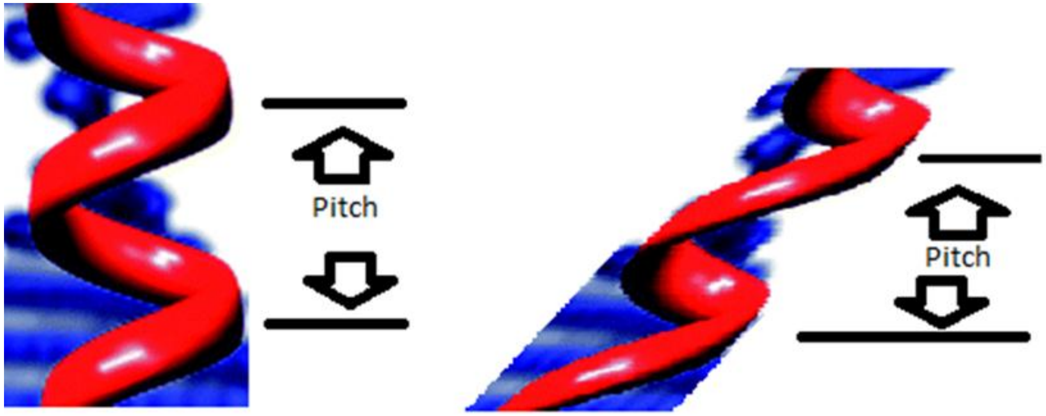


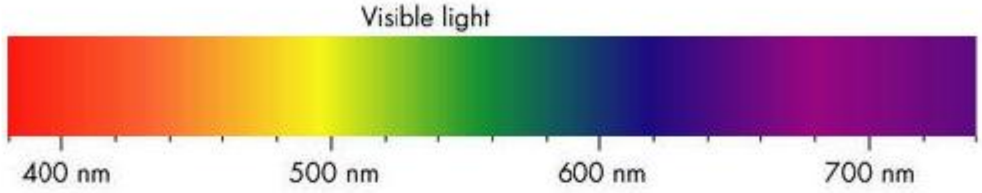
- **Pros**
  - **Good accuracy**
- **Cons**
  - **Requires two images acquired during a test – Complex**

Theory

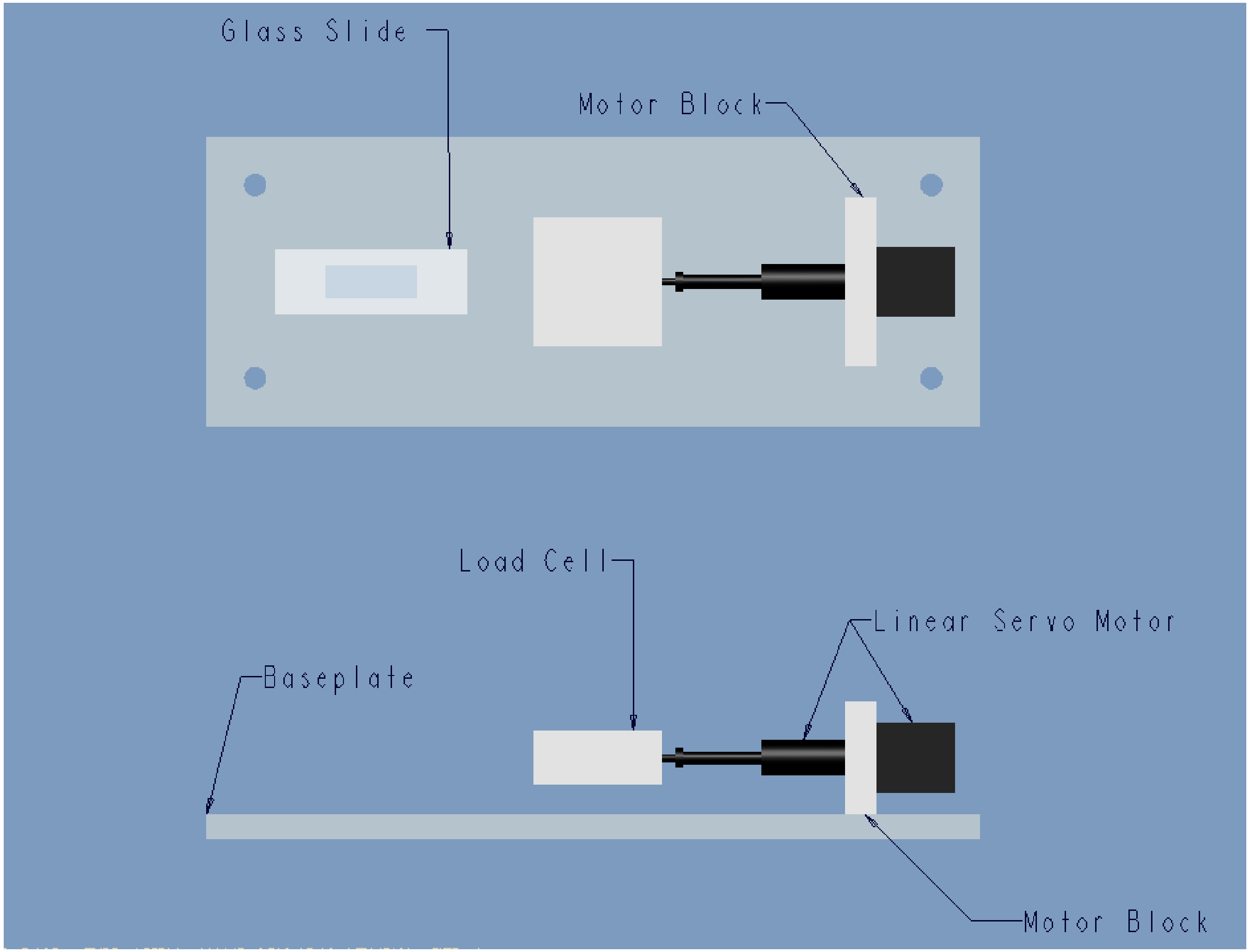
- $\tau = \text{Force/Area}$



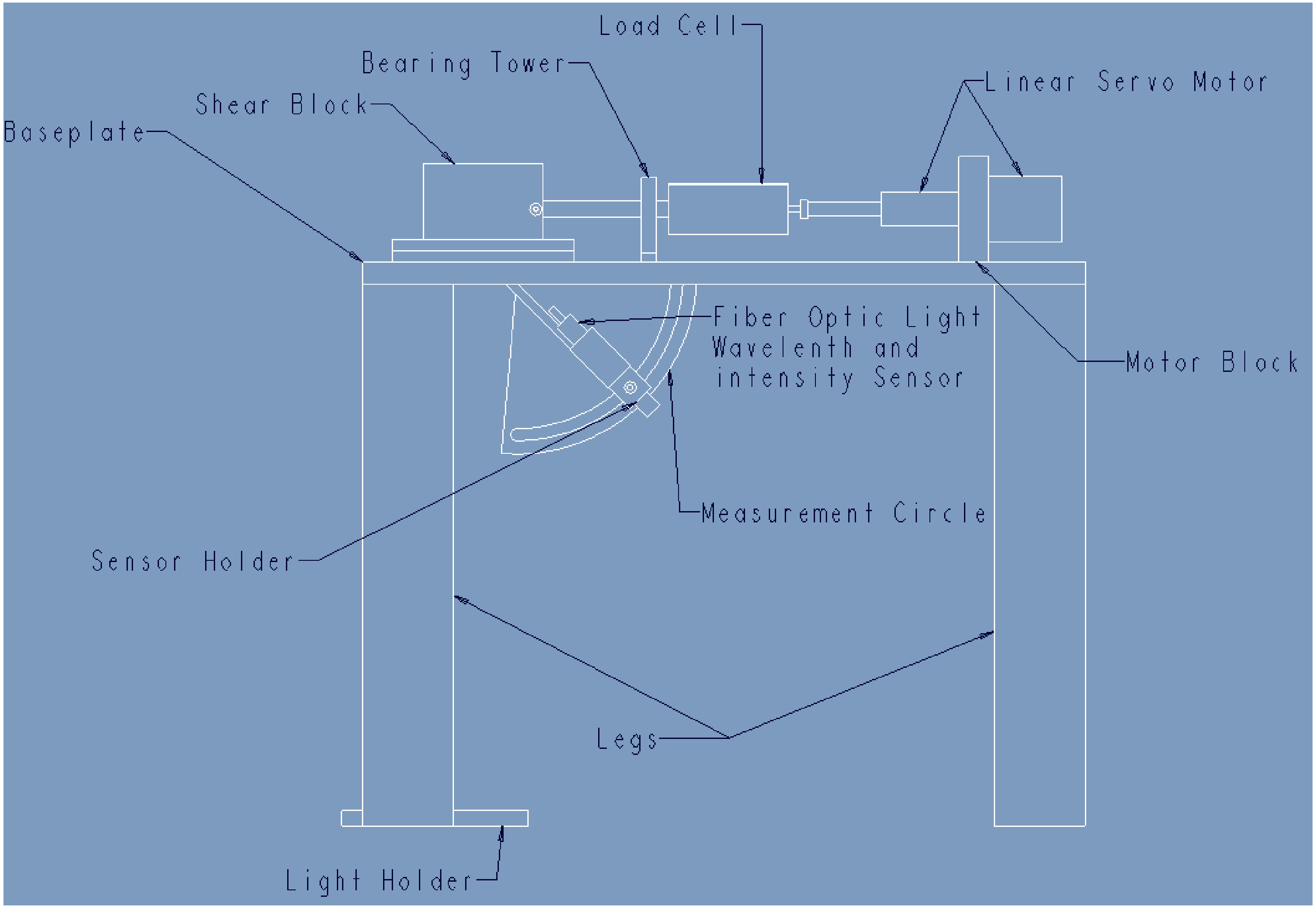




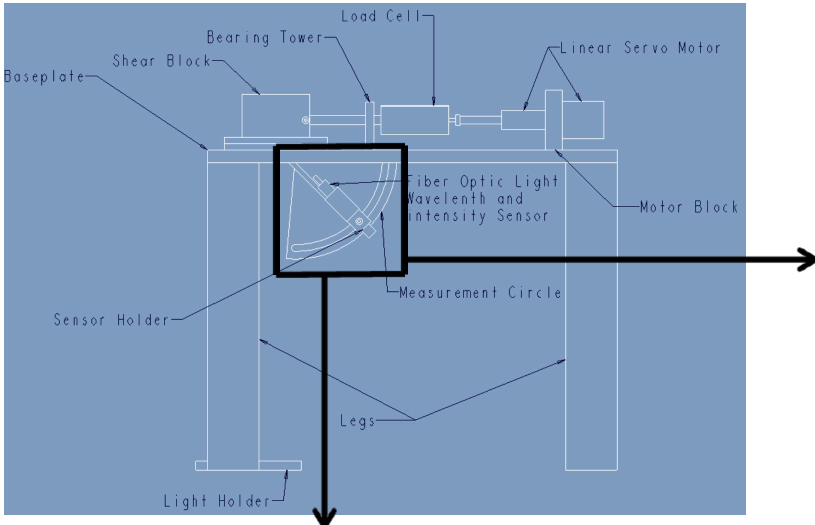
Given Parts and Design

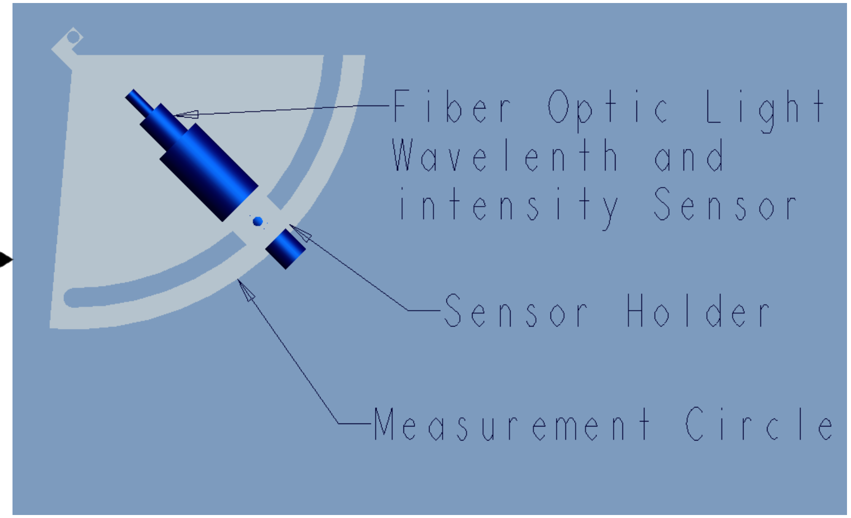


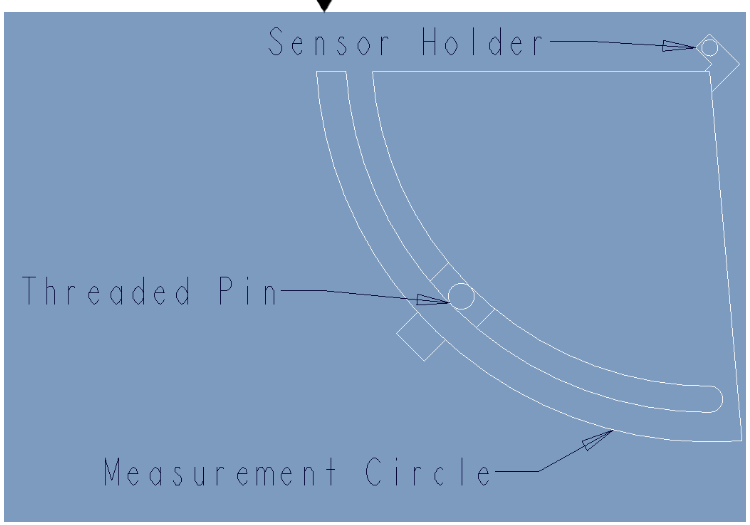
Final Design



Final Design

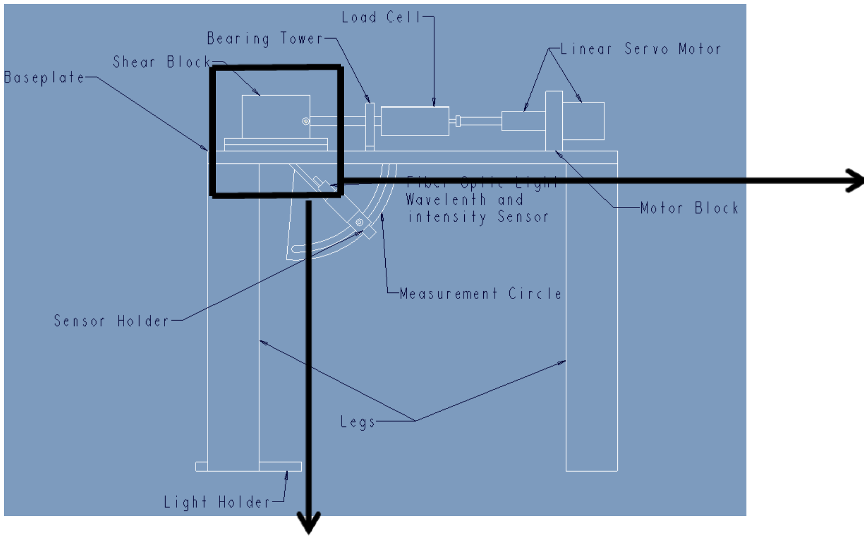


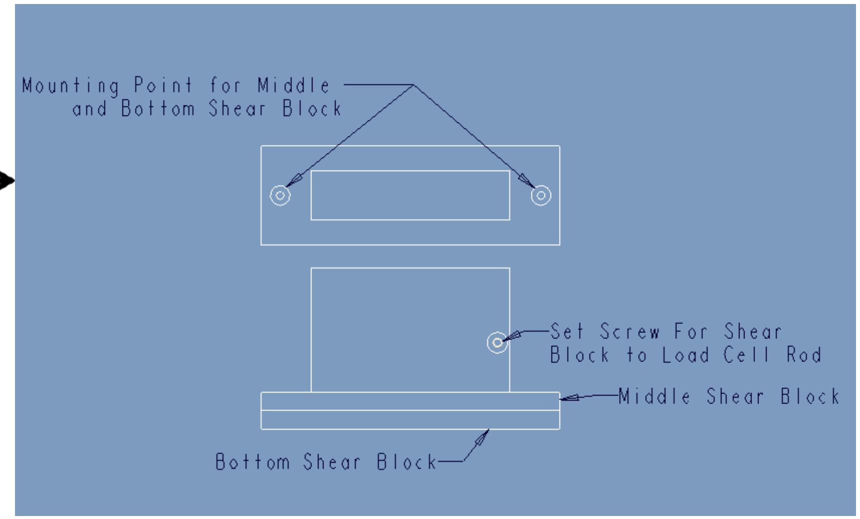


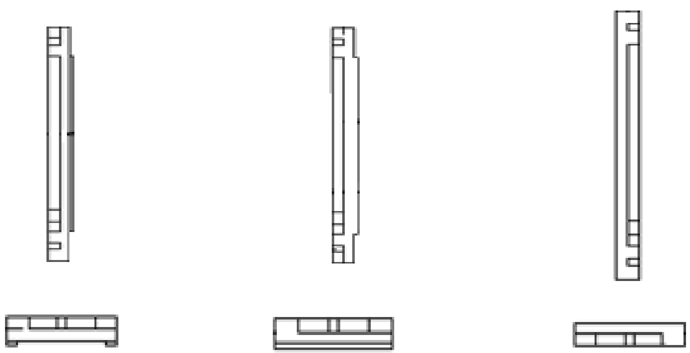


- **Threaded Pin will have a matching nut that holds the sensor in place**

Final Design







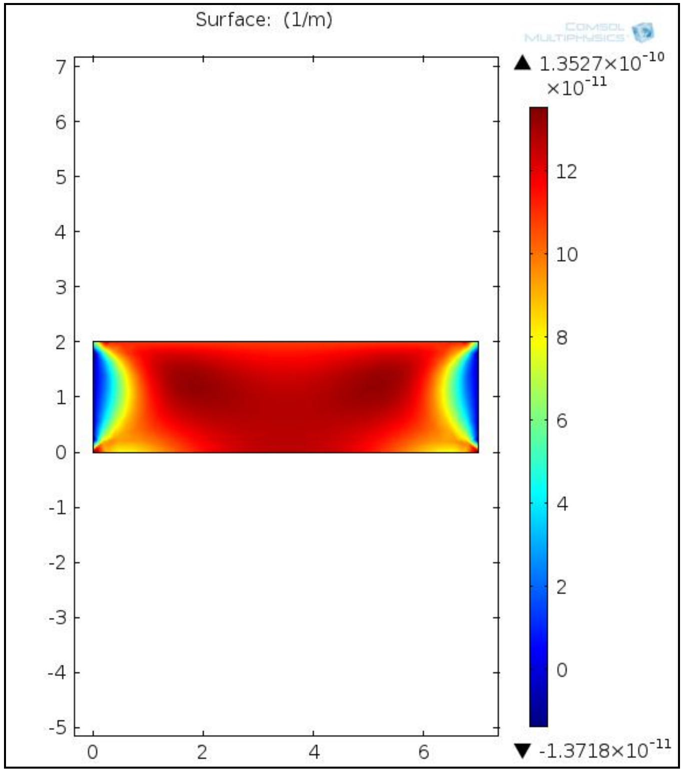
U-Shape   Extended Shape   Flat-Flush Shape

- **Bottom Shear Block holds the heat pad and is modular so different block types can be tested**

LabView

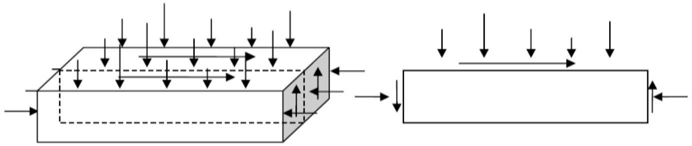
- Correlation to shear load and voltage
- Load cell, servo-motor, spectrometer
- All need to start at the same time – record information
- Import data to MATLAB

Simulation - FEM



Strain XY

Plane Strain



$$\varepsilon_{zz} = \varepsilon_{xz} = \varepsilon_{yz} = 0$$
$$\sigma_{xz} = \sigma_{yz} = 0$$

$$\begin{bmatrix}\sigma_{xx}\\ \sigma_{yy}\\ \sigma_{zz}\end{bmatrix} = \frac{E}{(1+\nu)(1-2\nu)}\begin{bmatrix}1-\nu & \nu & 0\\ \nu & 1-\nu & 0\\ 0 & 0 & 1-2\nu\end{bmatrix}\begin{bmatrix}\varepsilon_{xx}\\ \varepsilon_{yy}\\ \varepsilon_{xy}\end{bmatrix}$$

Purchase Order

McMaster-Carr

Part	Description	Quantity	Unit Price
Teflon Bearing	Sleeve Bearing for 1/4 ” shaft diameter, 1/4 ” length	1	$ 3.11 each
Insulation	Ultra-Thin Insulation	1	$9.03 each
Heat sheet	Ultra-Thin Heat Sheet- 10 Watts per inch^2	1	$38.90 each
M2.5x45 Screw- 3mm	18-8 SS Metric Pan Head Screw- M 2.5x45- Length 3mm (Pack of 100)	1 pack	$4.48
M2.5x45 Screw- 10mm	18-8 SS Metric Pan Head Phillips Screw- M 2.5x45- Length 10mm (Pack of 100)	1 pack	$ 5.21
10-24 Screw- 3/4 in.	316 SS Pan Head Phillips Screw 10-24 Thread- Length 3/4 in. (Pack of 25)	1 pack	$5.61
		Subtotal	$66.34

Purchase Order

LED Supply

Part	Description	Quantity	Unit Price
LED	Carclo 20mm Luxeon Rebel-EndorStar Optic	1	$5.99
Lens	Medium Ripple Lens and Lens holder (19° Illumination Pattern)	1	$3.00
Lens Color	Neutral- White	--	- -
Case	Aluminum LED Housing with 1/2” NPT Thread w/ 6” wire leads	1	$14.75
		Subtotal	$23.74
		Project Total	$90.08

Bill of Materials

Part- Description	Quantity
Linear-Servo Motor (1/2” Motion)	1
Load Cell (1/2 N loading)	1
Power Supply (Up to 24 Volts)	1
Baseplate	1
Glass Slide (3”x1”)	3
Connecting Rod- Connection from load cell to shear block	1
Legs (9” length)	4

Part- Description	Quantity
LED	1
LED Holder	1
Motor Block- Support for the servo motor	1
Heat Pad (10 Watts per inch^2)	1
Insulation	1
Shear Block Top	1
Shear Block Mid	1

Bill of Materials

Part- Description	Quantity
Shear Block Bottom- Flush	1
Shear Block Bottom- Extrusion	1
Shear Block Bottom- U-shape	1
Support Bracket- Supports the connecting rod with the teflon bearing	1
Measurement Circle- Displays increments in degrees	1
Sensor Holder	1
Threaded Sensor Holder Pin	1

Part- Description	Quantity
Fiber Optic Sensor- Measures wavelength and intensity	1
Sensor Holder Pin	1
M2.5x45 -3mm Screw	6
M2.5x45 - 10mm Screw	6
10-24 -3/4” Screw	6
Teflon Bearing- Reduces the friction in the support and connecting rod	1

Schedule

- October- Complete apparatus design
- November- Machine parts & program LabView
- December- Order polymer before break
- January- Test static shear cases
- February- Test dynamic shear cases
- March- Analysis of data and research possible applications of the sensor
- April- Overflow

Summary

- Apparatus design is complete
- Machine shop is machining parts
- Parts have been ordered and received
- Programming will begin this month
- Testing will commence once programming and parts are completed

Questions/Comments