

ELLA 4.0 Standard Operating Procedure

PoSM Lab Summer 2025

Preparing the elastomer band

Elastomer

1. **Cut out material.** Measure out the dimensions you want on the rubber and cut with the rotary cutter. Cut over the cutting mat. The width should be between 5 and 12 mm and the length 50-150 mm. A default cut can be about 10 mm by 100 mm.

Note: If you are adding mass, check that the band will fit in the load mass adapter (shown in fig. #3). As of 01/07/24, the current maximum width of the load mass adapter is approximately 10 mm (11-12 mm fit sometimes).

2. Using a vice (shown in fig #1) and a white acrylic marker (shown in fig #1), stretch the material to approximately the strain it will be under in ELLA and mark spaced points in white marker. Place points every half-inch, in line with the marks on the cutting board. SLOWLY let the band retract.

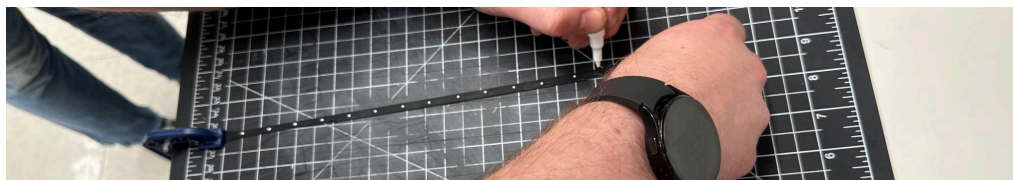


Fig 2. An example of a sample being marked with dots. It's attached to the counter by a vice, and is stretched to ~100% strain. Dots are evenly spaced approximately every half inch with a white acrylic marker.

3. Record band data in the [Recoil Lab Notebook](#) .

Mass the band in the US Solid balance (plug in, turn on, and tare before using. Check that the unit is in g or mg).

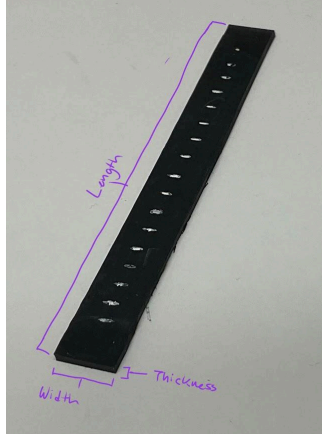


Fig. 3 Dimensions of a sample band.

Make sure you have recorded the **mass**, **length**, **width**, and **thickness** using the caliper. Also record the **date**, **sample ID**, and **material** in the lab notebook. See examples in previous entry as needed. (#TODO: add columns or column names)

Added Mass

5. Added mass can be added to the test material in 3 ways, with the small clamp and big clamp having masses of 1.1764g, 7.682g, respectively.

- a. Magnet on material (no clamp)
- b. Magnets on small clamp
- c. Magnets on bigger clamp

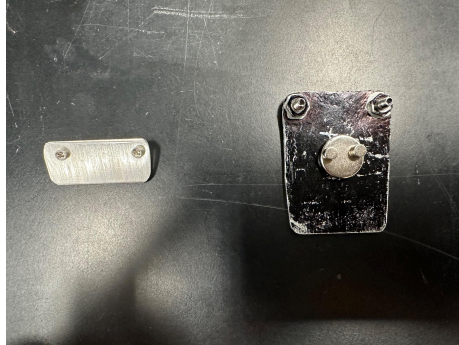


Fig 4. Two load mass adapters: a small clamp and big clamp with example of magnets attached

TODO: classification for the

6. Preparing the added mass comes with magnets of different sizes and weights that can be added on in those 3 ways

7. IF CLAMPING: Clamp, measure, and record (lab notebook) the amount of the sample in the Load Mass Adapter

- First place the sample on half the clamp and measure how much falls in the Load Mass Adapter ("Bottom Length Measured"). Close the Load Mass Adapter.
- Measure the portion of the sample out of the clamp ("Length After Load Mass"). Ensure the calculated ("Bottom Length Calculated") roughly matches the measurement from the previous step

WEIGH THE CLAMP WITH THE ADDED MASS BEFORE YOU PUT IN ANY MATERIAL!!! Then record in the lab notebook under column E which should add this mass plus the added band mass in column J. THEN record this added mass (M) value in the GUI.

Tape the magnets to the outside of the load mass adapter. The tape should cover the shine of the magnets to avoid any confusion in the footage. Using the white acrylic marker, place a dot on the load mass adapter roughly as low as the elastomer goes, err on the side of being too high

%add picture of a taped sample in each load mass adapter w/ dot

Fig 6. We add a dot to the load mass adapter to track the position of the load mass.

Setting up ELLA

Warning: some ELLA software will take a long time to load. Try to be patient and give things ample time to open/work before pressing a button again as that will probably just make things worse.

Computer/Software/Hardware

9. Turn on the Computer
10. Turn on power strip bar
 - a. Make sure the red thing plugged into the computer has a green light before launching the matlab app (see top left of fig. 5)
11. Open the ELLA software by clicking the shortcut on the desktop named "Launch ELLA Shortcut".
12. Connect all arduino boards as well as necessary power supply for circuit boards

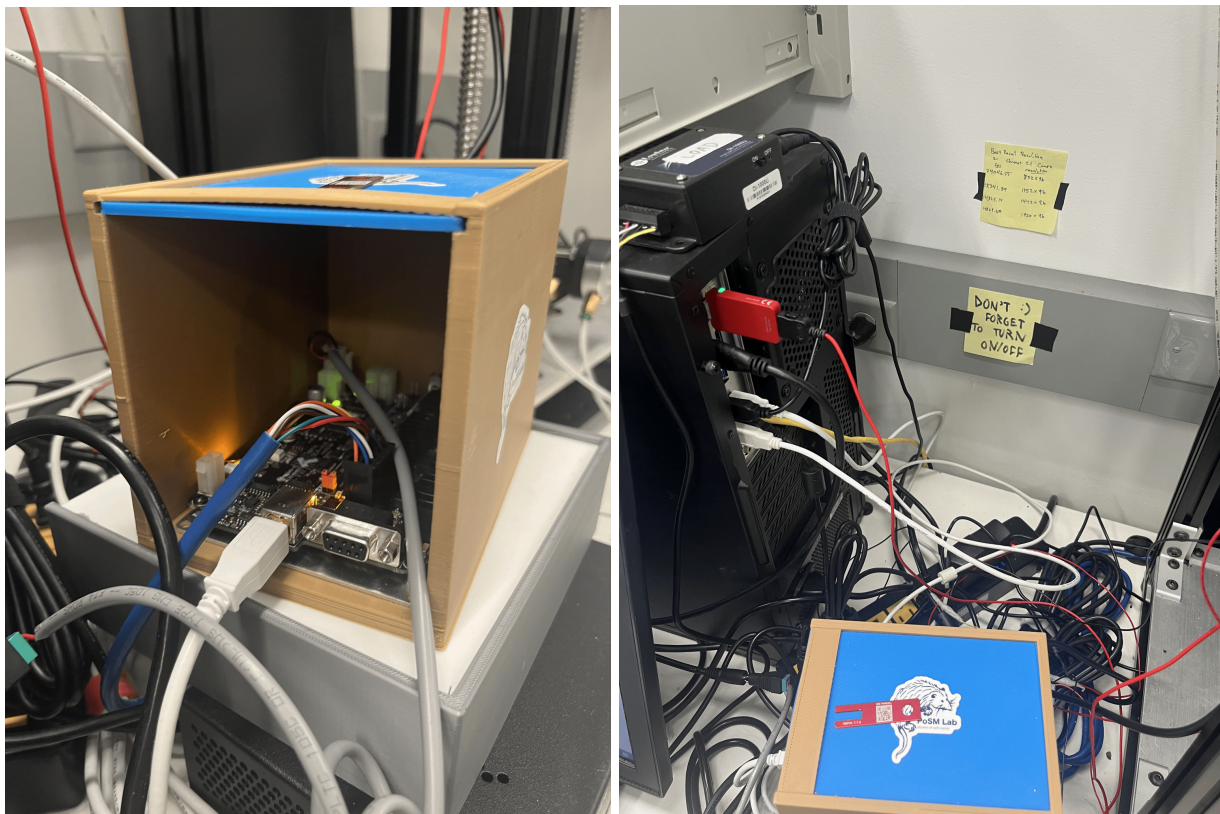
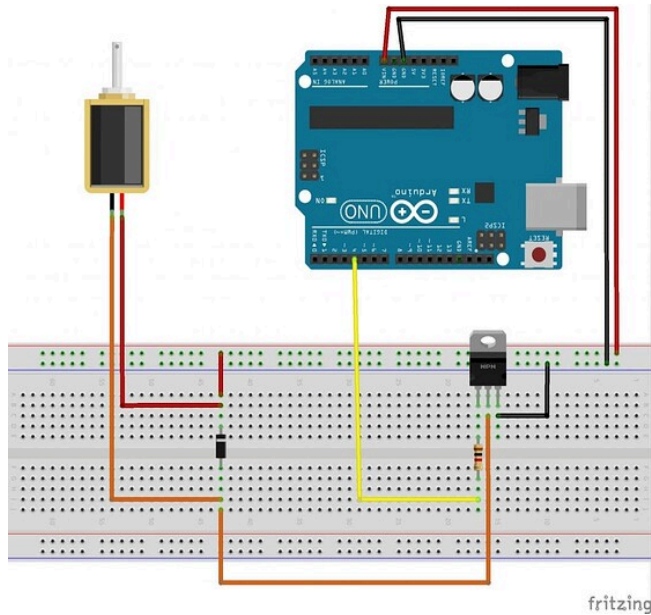


Fig. 7: Custom electronics live inside the brown 3D printed box. Trust that they work, I sure do.



Compressed Air Cylinder

13. Turn on the Compressed Air Cylinder (don't move the cylinder)—by rotating the top, silver knob (the cylinder knob, see fig 6) counterclockwise.

- Open needle valve (black smaller valve above needle on the left of the two dials,
- We want approx 100-150 PSI on the dial on the left is a value we want. The values don't have to be that precise. You can use the valve marked "regulator" to change the left valve to if needed. There may be a slight delay in twisting the valve and the readout on the valve.

Note: remember to close when leaving (can use sticky note as reminder)



Fig. 8 Needle valve (left), two dials and regulator (middle), cylinder valve (right)

Preparation I (only for initial set up)

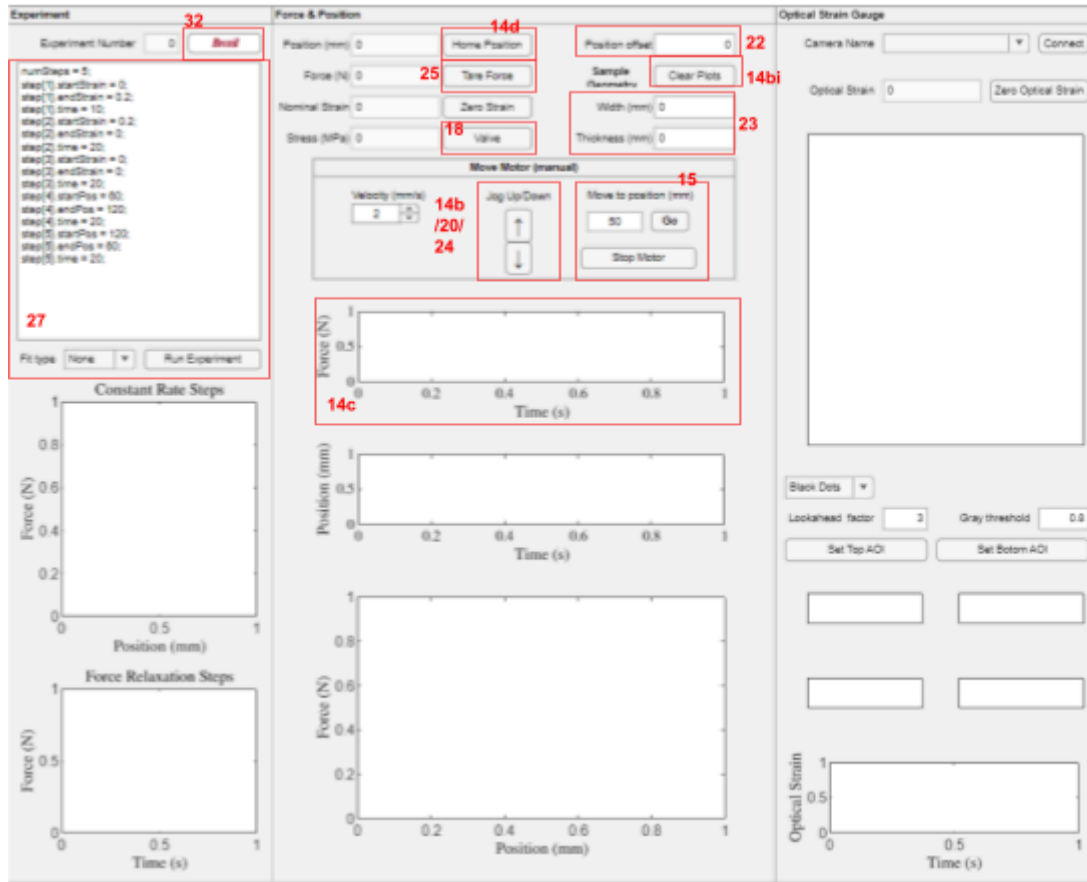


Fig 11. ELLA GUI, buttons are numbered according to the step in which they are used in this SOP (mostly)

14. Home position.

You only need to home position at the beginning of the day/before your first experiment of the day

- Remove the black supports on each side of the force sensor + top clamp setup #TODO: add image of the black supports
- Bring the position down to the bottom
 - You may want to close the clamp (with nothing in it) for more precision
 - With the velocity at 2 to 4, press the down arrow once to begin movement. Pressing it again will stop movement. The lead screws (the big long ones) may appear to wobble when it moves at higher velocities but this shouldn't be an issue.
 - Stop (by pressing the down arrow again) when the top clamp is about to touch with the bottom clamp (like ~1mm you can get really close). You can also stop it by pressing the "Stop Motor" button.
 - Press "Clear Plots" when necessary

- c. Press “home position” button ELLA GUI
 - i. This will slowly move the force sensor down until it hits the clamp and set that position equal to zero.
 - ii. IF there is an error message about the FUTEK sensor, unplug the red USB connection and plug it back in, then press the button again (goes with every FUTEK error)

15. Move stage to fit the test material (using known length), write a specific value in mm under “move to position (mm)” and press the “Go” button

Preparation II (repeat for each experiment as needed)

16. Unclamp top clamp using the red snap-on torque screwdriver at 5 inch lbs. There are two things that you can unscrew on ELLA, it is the bottom, back one. The top, front one exists to be tapped by the solenoid. If, during an experiment, the material slips out of the top clamp, you may increase the torque or use another tool. (torque can be adjusted by pulling the bottom of the tool down and twisting it. When adjusted to the level you want you can snap it back into proper alignment)

17. Clamp in test material

Using the torque screwdriver, unscrew the top clamp until there's a sufficient gap for the band's thickness (eyeball it/feel it out with your finger). Feed in the top of the sample, then screw each screw in all the way, one before the other. You'll have to hold the nuts on the back of the clamp with a wrench while you screw. If the band is noticeably slanted after both screws are all the way in, retry.

18. Make sure the manual pneumatic switch is in the open position

19. Press "Valve" button to open the pneumatic solenoid valve

20. Jog motor down until the load mass is able to be clamped inside the bottom clamp

- a. Ideally as little as possible that it would hold
- b. To make sure the sample recoils straight up, make sure you pneumatically clamp the load mass adapter directly below the top clamp. Often, it will not be centered in the pneumatic clamp.

21. Holding the load mass adapter with tweezers or equivalent (keep your fingers out of there), Close the manual pneumatic switch by pulling down or towards the user; once the clamp is closed, press the "Valve" button on the GUI to close the pneumatic solenoid valve

22. Measure the position offset using caliper/ruler (amount of load mass adapter sticking out above the bottom clamp) and input into the GUI next to "Position offset" in mm

23. Record Width, Thickness, material, and load mass in the lab notebook and enter it into GUI,

24. Jog motor up so that the test material is at its rest length, at around .2 N on the force graph. Based on testing, if you let the material relax from there, it should return to ~0 N. This will be material dependent, so if possible, get a feel for how much your material relaxes. Wait ~3 mins to allow for relaxation.

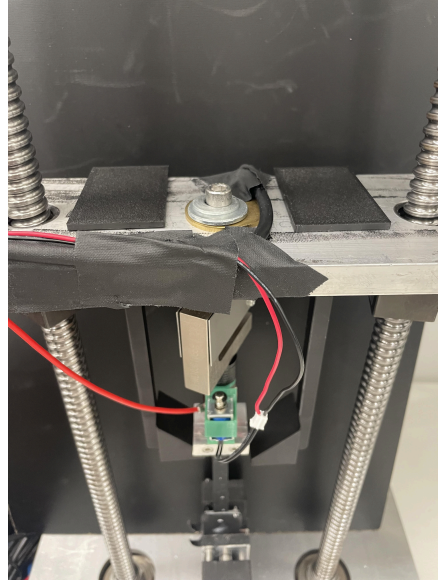


Fig 13. The grey plastic things that clip onto the flat bit of ELLA's translation stage are force sensor protectors. They prevent the band or load mass adapter from striking sensitive equipment, in particular the force sensor.

25. If there is added mass, attach the **Load Mass Protectors** (see Fig. 7) onto the metal slab

26. Record "Equilibrium Length" in the lab notebook using the number next to "Position (mm)", and little m should be automatically calculated inside of the lab notebook. Our convention is that "little m " is the total band mass outside of the load mass adapter.

a) Press "Tare Force".

- Expect a popup saying "taring force sensor" to popup and then automatically close when it's done
- After a short delay, another popup saying "Taring FUTEK" will also popup and auto-close

b) Press the "Zero Strain" button on the GUI

27. We then "warm up" the material, which gets the material used to large deformations (Mullins effect) and standardizes the viscoelastic state before recoil. This process also doubles as a measurement of the quasi-linear elasticity. Make sure you've recorded the width, thickness, material, and load mass metadata in the ELLA GUI or you won't be able to analyze the data later. We use the following matlab code:

```
numSteps = 5;
step{1}.startStrain = 0;
```



```
step{1}.endStrain = 1;
step{1}.time = 100;
step{2}.startStrain = 1;
step{2}.endStrain = 0;
step{2}.time = 100;
step{3}.startStrain = 0;
step{3}.endStrain = 1;
step{3}.time = 100;
step{4}.startStrain = 1;
step{4}.endStrain = 0;
step{4}.time = 100;
step{5}.startStrain = 0;
step{5}.endStrain = 1;
step{5}.time = 100;
```

Press “Run Experiment”. While the experiment runs (which will likely take 5-10 minutes), begin setting up the video camera.

If working with a stiffer material (such as a 60a material) you will likely need to reduce the end strain. Make sure this is documented in the Recoil Lab Notebook as well.

```
numSteps = 5;
step{1}.startStrain = 0;
step{1}.endStrain = 0.6;
step{1}.time = 100;
step{2}.startStrain = 0.6;
step{2}.endStrain = 0;
step{2}.time = 100;
step{3}.startStrain = 0;
step{3}.endStrain = 0.6;
step{3}.time = 100;
step{4}.startStrain = 0.6;
step{4}.endStrain = 0;
step{4}.time = 100;
step{5}.startStrain = 0;
step{5}.endStrain = 0.6;
step{5}.time = 100;
```

Video Camera

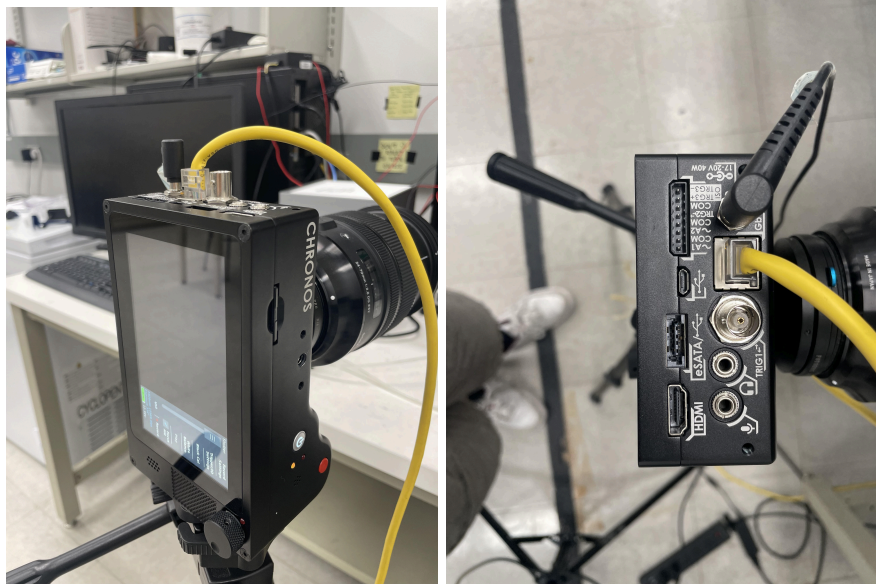


Fig 14. Yellow cable is the ethernet cable and the black cable is the battery cable. Insert the cables as seen in the picture.

28. Turning on the camera

- a. Turn on camera and plug in battery cable
- b. Wait until camera is fully turned on before plugging in the ethernet cable
- c. Make sure the lens cap is on and press “Black Cal” for black calibration.
- d. Go to “Util” and press “Network”
- e. Check the SMB connection where it should say:
 - i. Username: posmlab
 - ii. SMB Share: //134.173.33.159/Chronos_Videos
- f. Click on “Apply”
- g. To ensure the connection is successful, on the camera a window should pop up to say that the connection was successful.

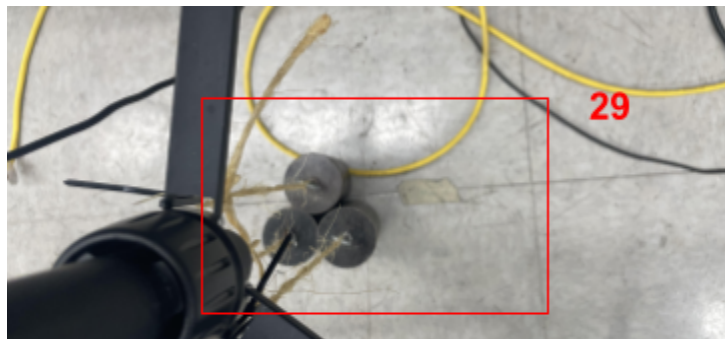


Fig 15. Floor marker where the tripod should approximately line up with ELLA view

29. Camera set-up

- a. Align the weights on to the marker on the floor then continue to adjust the camera as needed

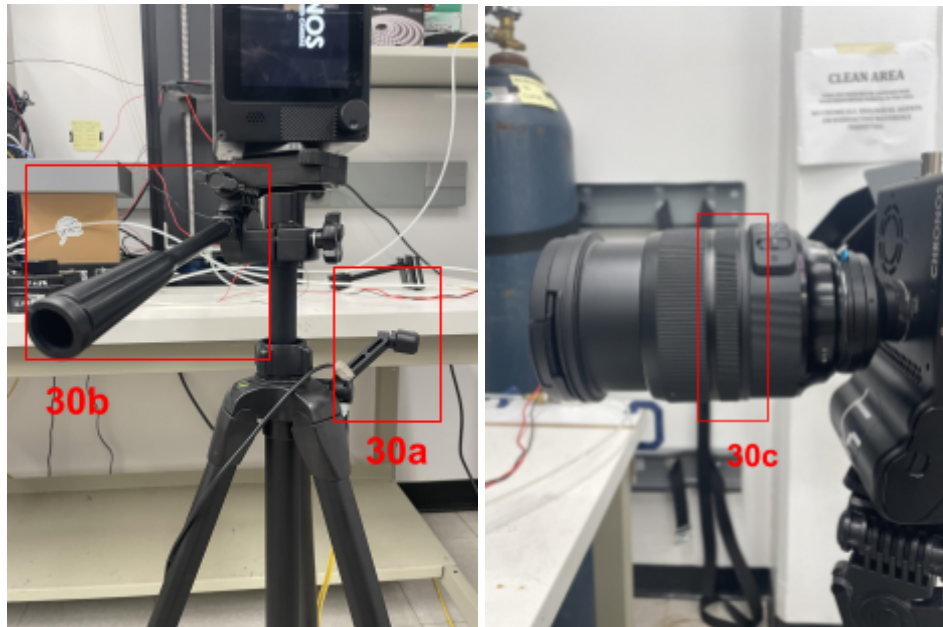


Fig. 16 Tripod and camera parts for adjustments

30. Camera adjustments

- a. Vertical adjustments
 - i. Use crank to move the camera up and down if needed
- b. Zoom/tilt adjustments
 - i. Make sure that the bottom clamp is still visible in the camera
 - ii. If needed, adjust the tilt by the long handle. Unscrew the handle counterclockwise to loosen the camera and adjust the tilt. Screw it again clockwise when at desired position.
- c. Focus adjustments
 - i. Rotate lens left or right.
 - ii. *Note:* The blue dots that appear on the screen are indicators of how focused it is. We want the most blue dots to appear on screen to ensure maximum focus.

31. Launch the Chronos interface to have control of the camera from the computer. (on google)

- a. Go to the search bar and type: 169.254.133.82
- b. Or visit the bookmarked page “camera”

Note: When the camera shows only a black screen, put the lens cap on and redo the black calibration by pressing on the “Black Cal” button.

After the warm-up stretching is done and camera is set up, you are ready to begin the recoil process.

Recoil

The Recoil GUI features a central graph titled "Force vs time (s)" with "Force (N)" on the y-axis (0 to 1) and "Time in seconds (s)" on the x-axis (0 to 1). Above the graph, there is an "Experiment number" field (0), a "Recoil" button (34b/35c), a "Re-initialize force sensor" button (35a), and a "Disconnect force sensor" button. To the right, there are "Camera Record Time (s)" and "Force Record Time (s)" fields, both set to 0. Below the graph, the "Additional Information" section (33) includes fields for "Material", "Equilibrium length (mm)" (0), "Sample ID", "Added Mass/m (g)" (0), "Mass/m (g)" (0), "Width (mm)" (0), and "Thickness (mm)" (0). To the right of the graph, the "Camera capture settings" section (35g) includes "Start Frame #" (0) and "End Frame #" (0), and a "Trim & save" button (35h).

Fig. 17: Recoil GUI

32. Press the red “Recoil” button on the ELLA GUI (fig 6), which should pop up the Recoil GUI (figure 11)

33. Record ALL the additional information necessary for data/filing, make sure that Mass/m(g) is the value from the Recoil Lab Notebook Column Q (m calculated), not N (total band mass)

34. Tap test

- Before going forth to the recoil test, it is important to do a tap test to ensure that the connections are working (to ensure that the tapper and force sensor are working)
- Make sure the lever is in the closed position (towards the user) THEN press the “Recoil” button on the Recoil GUI
- The software will run for a few seconds and then

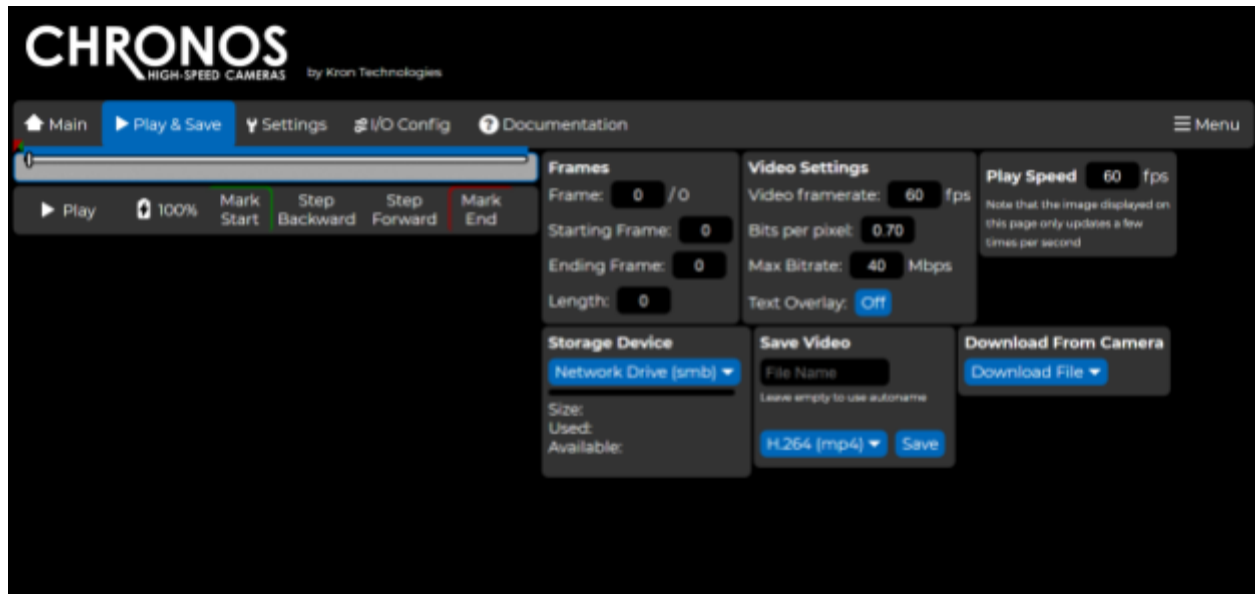


Fig. 18: Online Chronos interface under the “Play & Save” tab

35. Recoil

- a. Press “re initialize force sensor”
 - i. Safety: put on safety glasses to prevent life threatening dangerous chemicals flying everywhere
 - ii. But for real, do use eye protection. Worst case scenario you get an F magnet in your eye.
- b. If there is a load mass, Make sure the yellow lever is in the closed position, pointing away from you. Otherwise leave it open.
- c. Open valve w/ black lever
- d. Press the “Recoil” button
- e. When box says, “please enter camera capture settings,” switch over to chronos interface in Chrome browser
- f. Open the yellow lever to relieve the pressure in the clamp
- g. Press the “Play & Save” tab (figure 12)
- h. Goal: trim the video down to include before the tap starts and when recoil is done
 - i. Be conservative
 - ii. Use the Mark Start and Mark End buttons
 - iii. You can use a combination of the play speed, play button, and dragging the white bar to optimize the trim
- i. Under the “Save Video” section, type: ‘rawExperiment_vid[insert your experiment number]’ (e.g. rawExperiment_vid316). Then make sure the format is an mp4 and click “save”
- j. In the Recoil GUI, enter the starting and ending frame numbers from Chronos in the “Start Frame #” and “End Frame #” textboxes
- k. Press the “Trim & Save” Button AFTER the video is finished saving in the chronos interface

Repeat

36. If it is necessary to repeat a measurement, or use the same material but change the clamp and/or add magnets for mass, exit out of the Recoil GUI each time before starting a new experiment of stretching and recoiling.

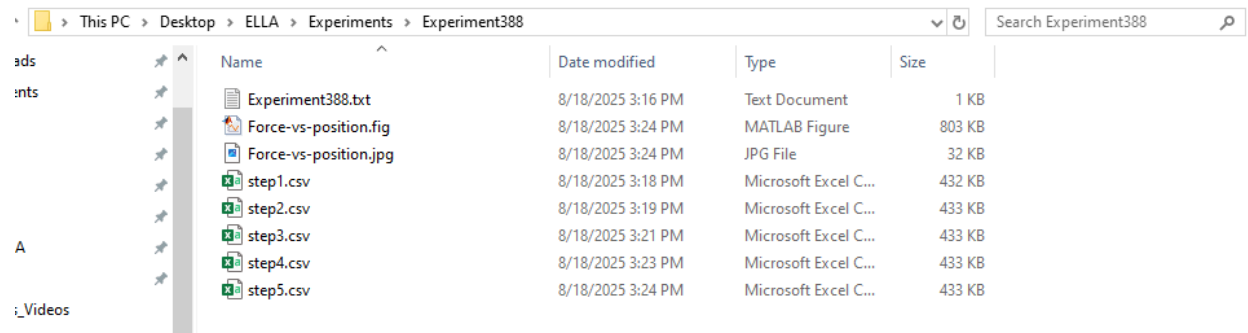
Transfer the data to the Posmlab shared google drive experiments folder [here](#). For each experiment, leave a folder named after the experiment (e.g. 316). In each numbered folder, include the experiment folder (e.g. Experiment316) and the recoil folder (e.g. 2.4494, but with the other experiment files within removed). This makes loading on the analysis computer easier, since you can drop the folders straight into the Experiment folder and Recoil/[your material] folder directly.

Data Collection/Post-processing

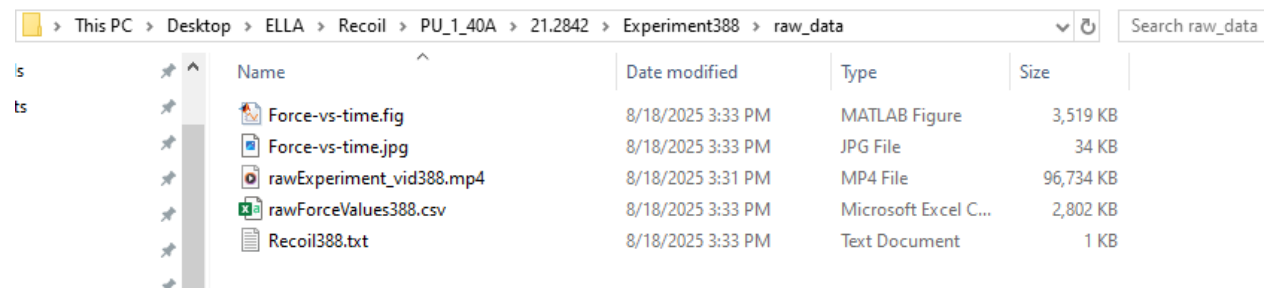
Overview: Now we want to transfer all the data to a different computer where all the data-analysis software lives. This computer is the one closest to the door. After transferring the files, go to that computer to analyze the data.

Transfer:

- Navigate to the **posmlab shared DRIVE**:
 - Open Experiments (marked with a green color)
 - Create a folder with the experiment number (eg. Experiment #388 would have a folder named 388)
- Navigate to the File Explorer on the Prince Charming computer
 - Navigate to: <C:\Users\posmlab\Desktop\ELLA\Experiments>
 - **Add the folder corresponding with the [Experiment#] to the drive folder**
 - For example: Experiment388



- Navigate to the <C:\Users\posmlab\Desktop\ELLA\Recoil>[your material]
- **Drag the folder corresponding to the added mass into the drive folder**
 - Within the folder should be a folder called [Experiment#] (eg. Experiment388) with a raw_data folder.
 - For example: Experiment 388 has material PU_1_40A and added mass 21.2842, thus we'd go drag the following folder into the drive
 - C:\Users\posmlab\Desktop\ELLA\Recoil\PU_1_40A\21.2842



- For all data processing, look at the title of the figure for instructions on what to do. You might have to enlarge the window to see the title. Detailed instructions are below.

Recoil data Processing

The data processing files can be found in our posmlab Github repository:

<https://github.com/posmlab/Recoil>

Read about recoil processing in the recoil processing SOP: [Recoil Processing SOP](#)

\begin{General Wisdom}

A central trade-off in regressions, but also machine learning is underfitting vs. overfitting. See fig. #TODO. If our fit isn't complicated enough, we haven't done anything useful, and we'll miss the underlying pattern. If our fit is too complicated, it'll pick out patterns in our data that aren't meaningful and we'll miss the underlying pattern.

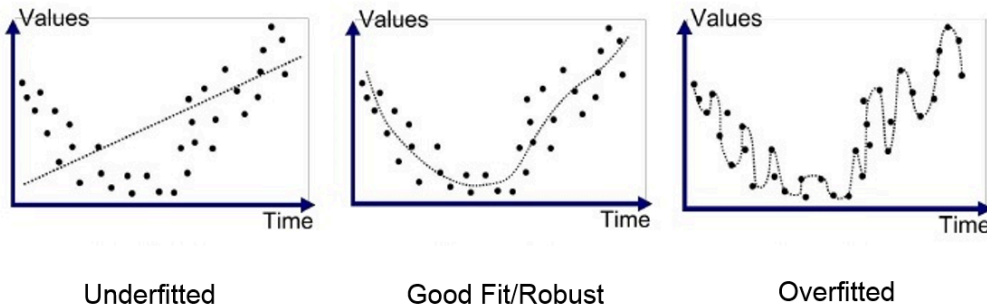


Fig. #TODO

The algorithm we use to fit is called “free-knot spline fitting.” tl;dr we’re fitting small degree polynomials to slices of our data. Each limit between slices (for us, it’s a vertical line at a certain time value) is called a “knot.” In our case, the knots are “free,” meaning they can move around to add more sensitivity to our fit in different regions. This is helpful, since the time before recoil is less important to us than while the elastomer is moving. The more knots we have, the more complicated the fit can be. So we can tune how complicated our model is by changing the number of knots. We control this via the “knot removal factor” box in the GUI. The bigger the “knot removal factor,” the easier it is for knots to be removed, and the less complicated the model.

All this to say, **tune Knot Removal Factor until the fit looks good, not underfitted/overfitted.** If you have a good reason to think $\text{Slope} > 0$ is possible or initial slope $\neq 0$, include that, but your data is questionable.

Henrik Barck created a really nice MATLAB notebook that helps to explain how freeknot spinefitting works and the effect of some of the parameters that you can tune:
https://drive.google.com/file/d/1aQgITW3BmY9HWc_tPaIDRG3QYV1ITK1J/view?usp=drive_link

Talk to Prof. Ilton if you have questions.

\end{General Wisdom}

First, hit the “choose ” button. t_0 is the time when recoil starts, so in the graphical input, click at the x-value just before the data starts to go down. This makes sure that any fitting we do only fits to the part while recoil is happening.

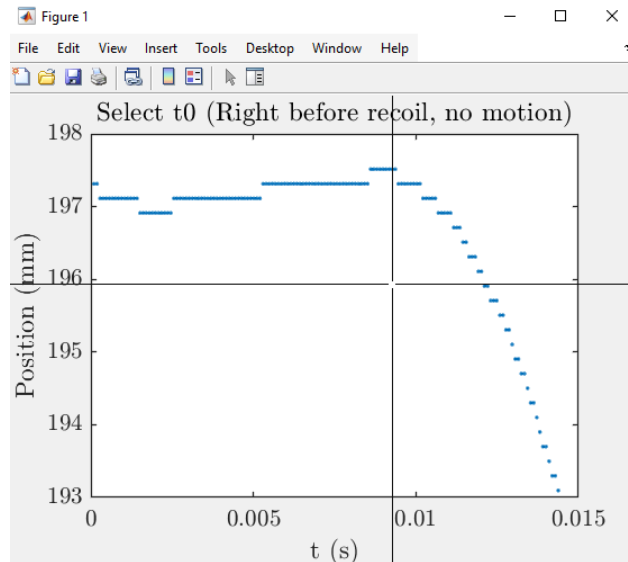


Fig #, the “select t0” window where clicking will save the time value where recoil starts. Try to click at the end of the flat region before the large dropoff in position.

For “Force Data,” simply press the “Load Data” button, and the fit will run using your given parameters. You should see a fun animation of the knots moving, and eventually a red fit over your blue data. At this point, you may change your parameters and load the data again to get a better fit. Once you get a satisfactory fit, press the “save fit” button.

“Position Data” is similar. What’s different is that we have to make fits to the position vs. time curves of each dot. Pressing “Load Data” will automatically run fits for each dot, and you can inspect the Nth fit by selecting the drop down window labeled “Dot N”. You can refit each individual dot’s position by pressing “Refit current dot.” This can be tedious. Ensure the fit for EACH DOT is satisfactory before pressing “Save Fit”.

From here, the analysis is yours to do. Files containing force and position data/fits should live in the following path on the nice computer:

C:\Users\posmlab\Desktop\ELLA\Recoil\[material]\[added mass]\Experiment#\analysis

Some potentially useful matlab files to know about:

calcResilience.m -> calculates resilience and max power for a specific trial

bulkProcess.m -> a function that calculates average summary statistics over an input vector of experiments, also calculates the SEM

simulateRecoil.m -> simulates recoil 😊, used to compare against theory. Based on Anita Chen’s thesis

simulateExperiment.m -> simulates recoil according to the parameters of a given experiment

compare_expsim.m -> compares an experiment to its simulated counterpart. Requires simulateExperiment.m to already have been run on the experiment

get_c -> fits a neo-hookean model $\text{stress} = c \cdot (1 + \text{strain} - (1 + \text{strain})^{-2})/3$ to the loading/unloading data of a given experiment

get_sim_workspace -> gets the path of the workspace full of relevant variables (stress, strain, nx) from a recoil simulation

get_finalAnalysis_path -> gets the path of the workspace from the experimental analysis

Helper functions:

Shutdown Procedure (ELLA)

Generally aim to turn things off in the reverse order that they were turned on. This system isn't as sensitive so things will probably not break if the order is slightly different.

Remove any sample if not already removed. The top clamp can be released by unscrewing it (with the red snap-on torque screwdriver as before) and the bottom can be released pressing the "valve" on the matlab app.

The **camera** can be left plugged in if you are using it frequently/everyday. You can turn off the camera by pressing the power button on the right side. If you press and hold it can clear the memory of the camera.

- **Close the gas cylinder.** First shut off the needle valve, then the silver knob
 - The pressure needles may remain the same for a few minutes but you should check to see that they've fallen to zero before you leave
- Exit out of Matlab
- Turn off the power strip on the table.
- Turn off the PC and monitor
- Put lens cap back on camera
- Try to leave important tools (torque screwdriver, Load mass protectors, etc) nearby or easy to find.
- Double check the valves on the gas tank are at 0

If the lab won't be in use for a long time, you may choose to unplug some instruments from the power strips, but be careful and note what should be plugged in where to restart the system.

Appendix

Full of very important information that you should read in its entirety
Language gets way more casual in this section btw.

Item Classification



Fig 1. Left to right:

1. a box magnetic screwdriver tips,
2. the adjustable screwdriver that accepts tips from the box,
3. a vice for stretching the band to add dots,
4. the rotary cutter (pizza cutter!) for cutting band from the neoprene sheet,
5. a caliper for measuring each dimension of a band,
6. a vise grip used for small screws/nuts,
7. and a white acrylic marker to draw dots on the band.
8. Cutting board

Magnets:

- a. Use the following table below for magnet weights



Fig 5. Left to right, corresponding to table 1.

A 3mmX2mm	B 8mmX2mm	C 10mmX2mm	D 12mmX2mm	E 15mmX2mm	F 32mmX2mm	H Rectangle
0.0904	0.6402	0.9933	1.4349	2.1978	9.393	13.8162
0.0878	0.6469	1	1.4927	2.197	9.4046	13.6226

0.0874	0.6457	0.9893	1.4325	2.2035		13.6579
0.09	0.6442	0.9787	1.317	2.159		13.5952
0.0901	0.643	0.9909	1.4515	2.198		13.6348
0.0916	0.6465	0.9861	1.4504	2.1959		13.7243
0.0893	0.6478	1.0057	1.4464	2.2072		13.6515
Averages	→					
0.089514286	0.6449	0.992	1.4322	2.194057143	9.3988	13.67178571

Table 1. Magnet weight reference (all in grams)



Fig. 12: The red snap-on torque screwdriver. It applies a set torque as it screws dictated by its readout in inch-pounds. There's a dial at the bottom that can be pulled out and spun to adjust the screwdriver's strength.

FAQ's and FEP's (frequently experienced problems D:)

How do I use this tool?

Using the rotary cutter:

- Line up a ruler with the edge you want to cut
- Run the rotary cutter back and forth along the bottom or top edge until a tear appears
- Follow the tear up/down the length of the cut, running mostly over the area where the tear ends
 - Make sure to keep the rotary cutter pressed against the ruler otherwise it's easy for the cutter to run off and make sideways lines
 - Make sure the band isn't being pulled into one direction and messing up the lines of the cut
- If you run over the whole length of the band, it basically won't cut anywhere except the top and bottom and you might damage the surface of the band.

Caliper procedure:

- Turn on, zero, and pull the black box down to the measurement you want.
- Caliper measurements can vary a lot, so several people should take the measurements for length and width and the average should be recorded in the lab notebook.
 - Have each person take each measurement 2-3 times.
- Thickness may be included or excluded as it will be uniform for the entire sheet of the material.
- Try to ensure that you're not compressing the band. Record the minimum distance where the band can slide in and out between the two prongs.

How to open and close the pneumatic clamp:

Before attempting to use the pneumatic clamp make sure that:

- The gas tank is opened
- ELLA is launched

The clamp in open position:

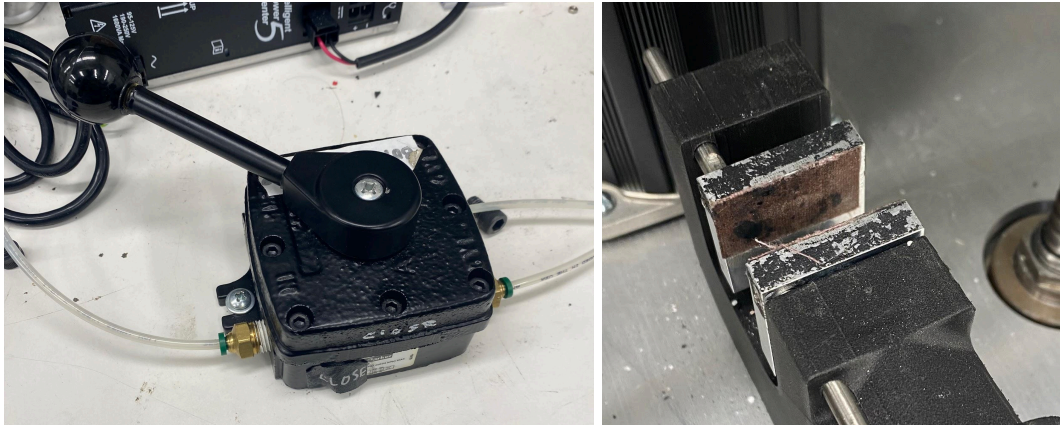


Fig 9. The switch is in open position (away from user) and open clamp

To close the clamp, pull the switch towards the user. The sides of the clamp are also labeled with



Fig. 9 Left: the switch is in the closed position (see the little piece of black tape on its front face that says “close”). This will ensure pressure is actively holding the clamp together. Right: the switch is in the open position. The clamp will stay closed, unless you press “valve” in the ELLA GUI.



Fig. 10 The pneumatic clamp. It can and will destroy your fingers, so be careful. Often, we load samples with tweezers. Left: the clamp is closed. Right: the clamp is open. Sometimes the metal face of the clamp will fall off the guard rail, you can just slide it back on when that happens.

My sht keeps falling out 🤨

Examples: band comes out of the LMA, LMA comes out of the pneumatic clamp before recoil, etc

Be strong! Patience is a virtue.

Bottom of sample gets pulled out of the Load Mass Adapter

Solution 1: Hammer that sht.

We (Charlie and Sophie) didn't put it in the SOP because it's not a necessary step but we also did it every time because it was way easier to pre-emptively hammer than to have to re-prepare the sample. It can be hard to hammer between the screws so we'd clamp with random pliers and hit the top of the pliers as a "good enough" measure. I'd typically hammer both sides (just a few light taps on each side)



Fig #TODO. Pliers around LMA, hammer positioned in location to hit the pliers.

Solution #2: Superglue 🤖

Make sure you do any appropriate measurements before supergluing things together (such as the mass measurements and length measurements).

How to remove the superglue:

- 1) Rip/scrape
 - Using the tweezers, you can carve out the band out of the LMA
 - You might damage the band or leave glue residue behind

- 2) Acetone bath
 - Taking a glass dish from the

Elastomer

Can I re-use an elastomer band?

Yes, if there are no visible physical deformations. These may include significant rips and tears. If the band gets overstretched it will also begin to get some light colored lines along the stretch direction. These lines indicate a plastic deformation, so the band should be retired.

What parts of the procedure should I repeat when I re-use an elastomer band?

- If the top part has stayed in the top clamp, there is no need to unscrew and re-screw it.
- After re-clamping, make sure to measure position offset again
-

Camera 📷

Camera doesn't display the buttons that I'm supposed to be seeing, what should I do about it?

I didn't really know how to fix this all the time so I'd just keep turning it on and off until things worked as expected. Unplugging the ethernet cable and replugging it helped things to work more consistently, but sometimes it'd work even if I plugged it in early and sometimes it didn't work when I plugged it in at the right time.

Camera screen is completely dark:

Have you taken off the lens cap 🙄

Have you turned on the Godox light? (labeled with "I hate futek" and "I forgive futek")

Other than that I'd just turn it on and off until it works. Sometimes it takes a few tries. Sometimes I'll also press random buttons but that is desperation (and generally ineffective)

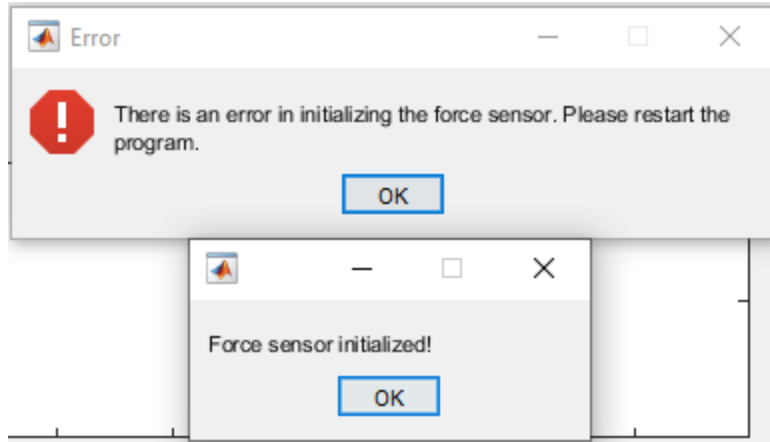
Camera screen seems frozen:

If the camera is connected to the network and accessible through the online site, check to see whether the site is in "Main" mode or "play & save" mode (play and save mode is what we use after administering a successful recoil). If the site is still in play & save mode, the camera will appear frozen. If it's in main mode, it should have normal live updates.

If that doesn't work, turn it off and on again.

Common Bugs 🐛

Initializing the force sensor:



This bug occurs often when pressing buttons like “re-initialize force sensor” or “tare force” or “zero strain”.

Fix:

- Find the red plug with a green light (connected to the red wire) and unplug it. It can be unplugged without causing major issues.
- Replug it
- Press the necessary button again
 - Especially if this issue occurs when pressing the “tare force” button,
- If it still doesn't work, continue unplugging and replugging until it does.

I recorded the data wrong before running experiment

If you cannot start running anything in the processing app

Check that the mass and geometry of the band are in the experimental text and recoil text, if they are not there fix it and save the updated files. Then rerun.

Load data doesn't work or smth.

You can go back into the text file and edit the experiment data by hand. The most important things to get right before are the position offset and the equilibrium length because those are used to measure the strain as it stretches out. Other than that if the other data is edited in post it's ok as long as it's correct in the books.

If Load data says it can't find the data, make sure the added mass and/or material in the Experiment.txt file are accurate. We store the videos in folders that are sorted by added mass and material, so the code won't know where to look if they're wrong.

#TODO: edit this section of the SOP bc it's not that clear im just word vomiting.

“Plot from Sync” not working

-Make sure your raw video can see a bright tapper contact the top clamp. If you don't have this, you won't be able to automatically sync your data. Adjust the top clamp so the camera can see the tapper make contact next time. (hold that L, your data might not be useable)

-If you see a peak in brightness in the popup towards the end of the video well past recoil. You can crop out the rest of the video. The easiest way to do this is to go to rawExperiment_vid#.mp4 and open with > photos. There should be a trim button in the top left of the photos app where you can

- You can manually change the sync frame, so if you can clearly see when the back of the tapper stops moving, you can choose that frame. We don't have software that can really go frame by frame, so this is suboptimal, but you can guess to within ~20 frames or so which can be good.

- If you agree with the sync frame and it still isn't working, make sure that the findpeaks function (under the app designer, 'plotfromsyncbutton' function) has an appropriate minimum value. If the value is too small, it'll find a peak too early. If the minimum value is too big, you'll catch nothing and get an index error since idx is empty.

Digitize isn't working

- If you don't see dots that you think should be there, open up adobe premiere pro and import your video file. Go to the top right where it says "Lumetri Color". Max out exposure, contrast, and mess with the whites and blacks sliders until the dots are pronounced.

Quick Ella Checklist:

(assumes an added mass):

Before assembling anything:

Have you measured and recorded:

- ☐ The length
- ☐ Width
- ☐ Thickness
- ☐ Band mass
- ☐ Added mass
- ☐ Planned bottom length?

Put the band in the LMA

Have you measured and recorded:

- ☐ The length after load mass

Now you:

- ☐ Hammered
- ☐ Covered the magnets and LMA with tape
- ☐ Add a white dot if there isn't one

CLAMP ELLA IN TOP AND BOTTOM, assuming the torque wrench has clicked and the pneumatic clamp good and everything's straight enough

Running ELLA:

Have you

- ☐ Homed position

Make sure you record:

- ☐ Width and thickness
- ☐ Material
- ☐ Load mass
- ☐ POSITION OFFSET!!

Bring it into equilibrium position (force = 0 ish)

- ☐ **MAKE SURE YOU ADD THE LMP NOW** 😭
- ☐ Tare force (taring force popup)
- ☐ Zero strain (taring futek popup)
- ☐ Record equilibrium length

- ☐ **Run experiment now** 😊

Press recoil

- ☐ Tap test
- ☐ Fill out all the information
- ☐ "Reinitialize force sensor"
- ☐ Open valve, recoil
- ☐

-