MSET Experiment 02 – Springs in Tension

Technical objective

The objective of this experiment is to measure the stiffness of 2 different springs and compare the experimental results to the manufacturer's specifications.

Background

The stiffness of a spring (K) is defined as the ratio of the load applied to the spring and the resulting elongation of the spring as is written in Equation #1. A spring with an applied load "F" is elongated a distance "L" as shown in Figure 1. This is usually expressed as a rate such as pounds per inch (lbs/in) or Newtons per millimeter (N/mm).

$$K = \frac{Applied\ Force\ "F"}{Elongation\ "L"} \qquad \text{eq. (1)}$$

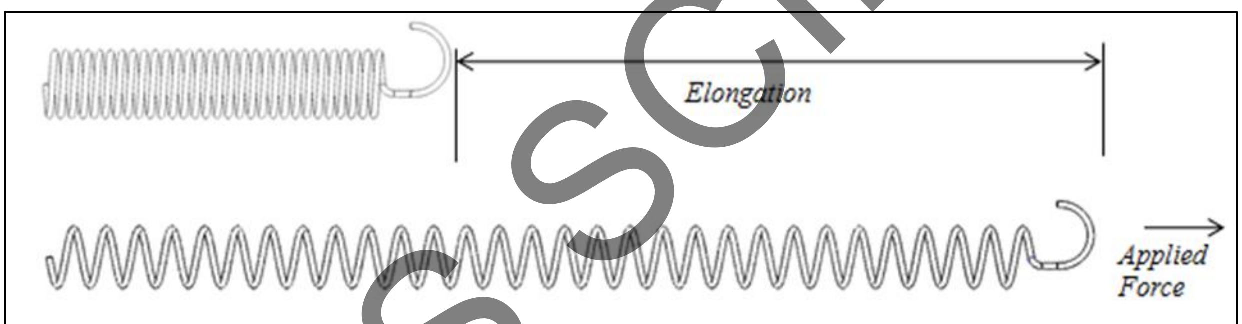

Figure 1- Spring Stretched with Applied Load

A spring's stiffness is typically linear as shown in the Load vs. Elongation plot in Figure 2. The stiffness is the slope of this line and can be calculated by knowing two points along the line as shown by Equation 2. The average stiffness can be determined by plotting several load and elongation values and fitting a linear trend line to the data and finding the equation for this line. This is also shown in Figure 2 by plotting the results in Microsoft Excel and adding a linear trend line and displaying the line equation. The spring stiffness plotted in Figure 2 has a value of 15.08 N/mm.

$$K = Slope = \frac{Change\ in\ Load\ (\Delta F)}{Change\ in\ Elongation\ (\Delta L)} \qquad \text{eq. (2)}$$

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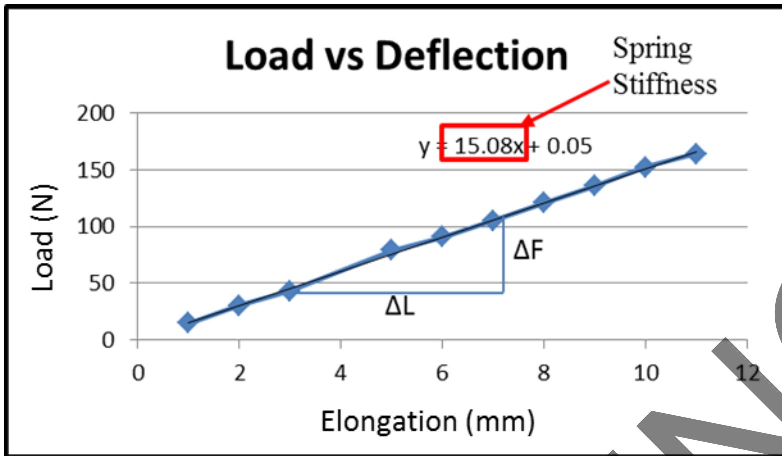


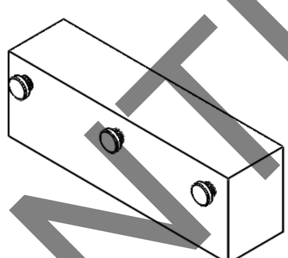
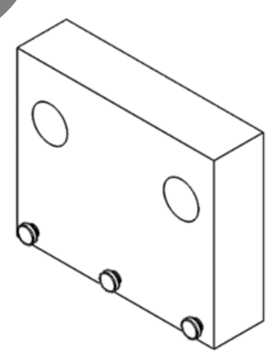
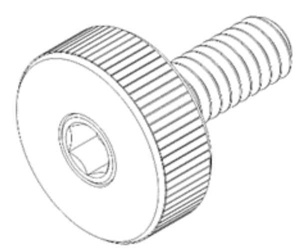
Figure 2- Plot of Applied Load vs. Elongation

Approach

In this experiment a set of springs will be individually stretched 20mm. The data will be plotted on an applied load vs elongation graph. Using 2 points on the graph the stiffness of each spring will be calculated. A best fit trend line will be applied to the data and the slope will be used to determine the average stiffness of the springs. Percent error will be calculated for comparison to the manufacturer's specification.

Experiment Setup

1. Gather the following components:

Carriage Spring Plate	Top Spring Plate	5/8" Thumbscrew
		

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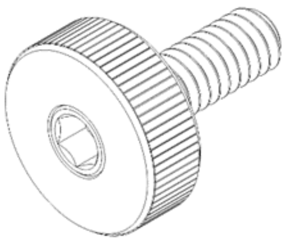
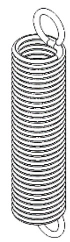
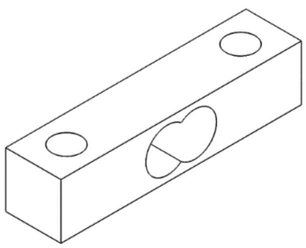
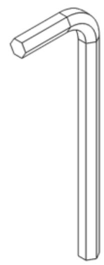
¾” Thumbscrew **x2** 	Spring 1 	Spring 2 
5kg Load Cell 	5/32 Hex Wrench 	

2. Attach the tower to the base plate as shown in the Quick Setup Guide. **Safety shield must be used for this experiment; it has been omitted from the following illustrations for clarity purposes.**
3. Use the 5/32 hex wrench to attach the 5kg load cell to the carriage with the arrow pointing up.

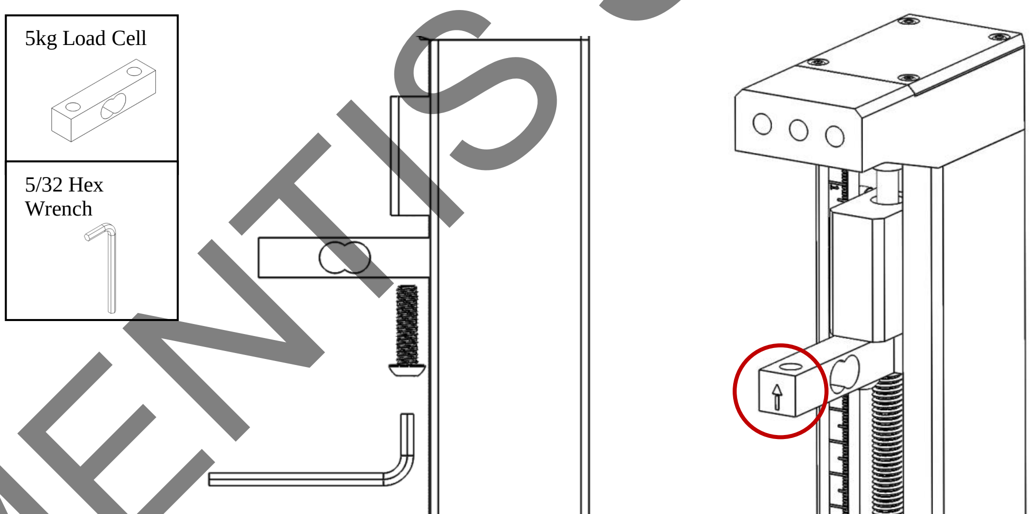


Figure 3. Load Cell Orientation

4. Plug the load cell into port 1 at the back of the SIM.

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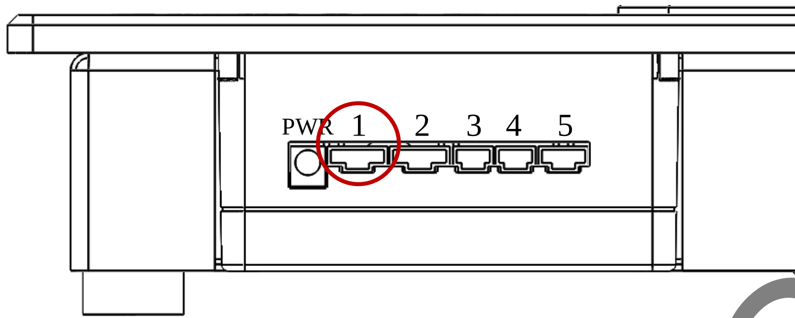

Figure 4. Port 1 on SIM

5. Connect the Carriage Spring Plate to the load cell with the 5/8" thumbscrew and connect the Top Spring Plate to the top mount using two 3/4" thumbscrews.

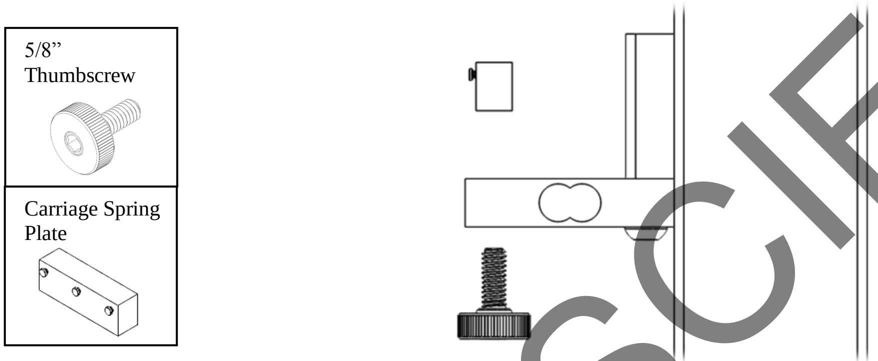

Figure 5. Attachment of Carriage Spring Plate

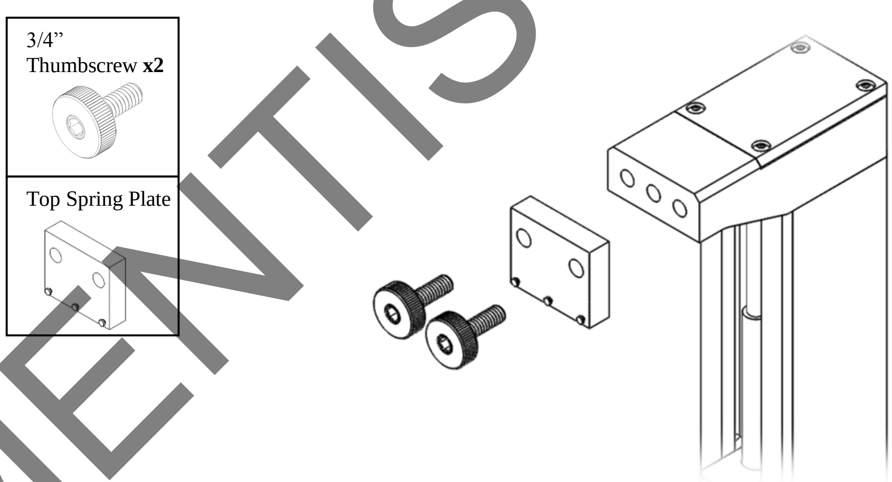

Figure 6- Attachment of Spring Plates to the Load Cell and Top Mount

<u>Experimental Procedure</u>

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1. Put on safety glasses.
2. In the MSET software, double click “Springs” to launch the springs in tension experiment.

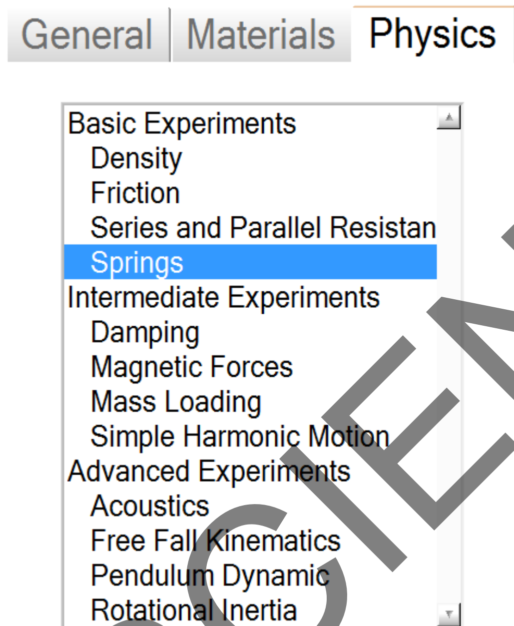

Figure 7. Location of Springs in Tension Experiment

3. Raise the carriage until the top is level with the 1.5 cm mark on the tower ruler

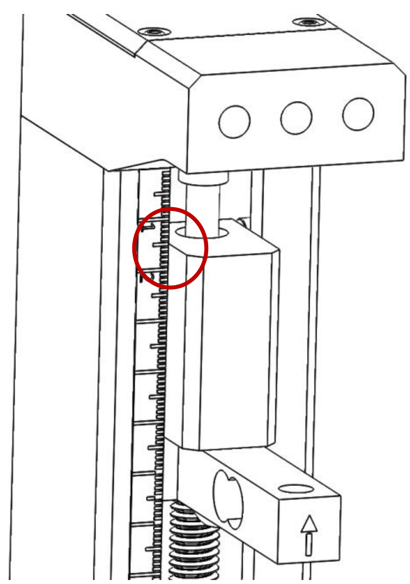

Figure 8. Alignment of Carriage

4. Attach spring #1 to the center pegs of the plates as shown in Figure . There will be a slight pre-load on the spring at this time

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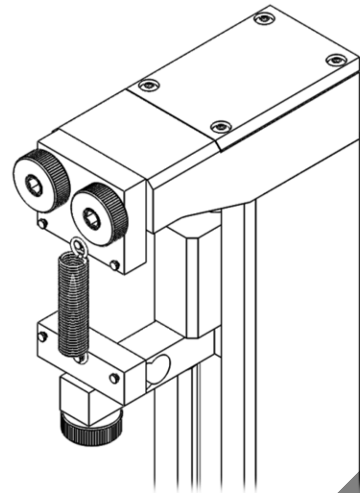

Figure 9- Spring 1 attached to Spring Pegs

5. Click **Start Measuring** to begin reading the sensors.
6. Click **Zero Readings** on the MSET program to zero the load and displacement readouts
7. Click **Log Data** to begin collecting data.
8. Lower the carriage until it has displaced 20mm as displayed on the MSET program

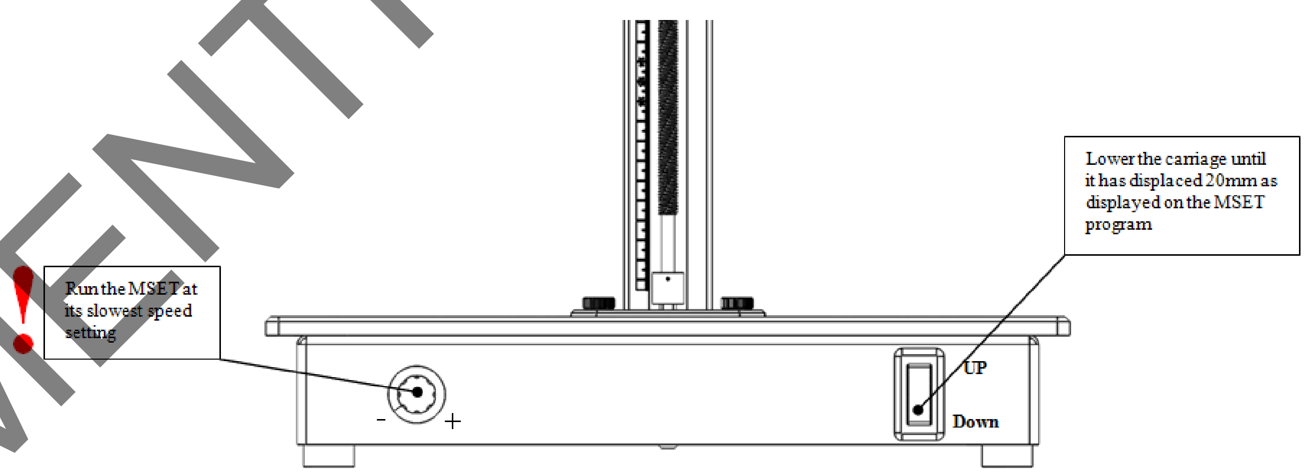

Figure 10. Experiment Operation

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9. When the final displacement is achieved, release the direction control switch and click 

.
10. The software will ask if you would like to save the plot. If satisfied, click “Yes”. This will save the plot within the MSET program.

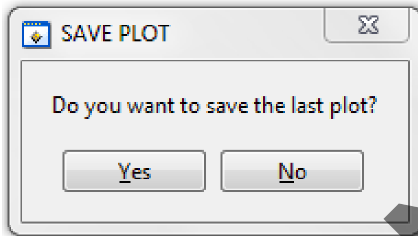
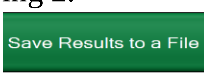


Figure 11. Save Plot Window

11. Record the ending load and displacement values in Table 1 in the data analysis section of this tutorial.
12. Return the carriage to the 1.5cm position and remove spring 1 from the pegs. Now attach spring 2 in the same configuration.
13. Repeat steps 4-11 using spring 2
14. Upon completing step 12 using spring 2, return the carriage to the 1.5cm position and remove spring 2.
15. Now press 

to save both data sets. Enter an appropriate filename and press ok.
16. The data collection portion of this experiment is now complete. Continue to the data analysis portion.

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Data Analysis

1. For each spring record the beginning and ending load and deflection Table 1. Calculate the spring stiffness using Equation 2 and enter in Table 1.

Table 1 - Spring Stiffness Calculations Based on Two Points

Spring 1	**Load (N)**	**Deflection (mm)**
Start	0	0
End		
Change (Difference)		
Calculated Stiffness		

Spring 2	**Load (N)**	**Deflection (mm)**
Start	0	0
End		
Change (Difference)		
Calculated Stiffness		

2. In the MSET StaticData folder, open the data saved from testing the two springs. Using a data processing program, such as Microsoft Excel, plot the load deflection data for each spring and determine the slope of each plot by adding a linear trend line and its equation. Report the average stiffness in Table 2.

Table 2- Average Spring Stiffness's From Linear Trendline

Spring	**Stiffness (N/mm)**
1	
2	

3. During the test, springs 1 and 2 were stretched 20mm. Determine how much force would be required to stretch each spring 60mm, 70mm, and 80mm.

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4. The manufacturer reports the springs to have the stiffness in the table below.

Table 3- Manufacturers Stiffness Specifications

Spring	Stiffness (N/mm)
1	0.455
2	0.212

For comparing experimental results to an expected result it is often useful to evaluate the percent error. Using Equation#3 below, calculate the percent error between the experimentally determined stiffness' (two point calculation and average trend line analysis) and the manufacturers specified stiffness. Record results in Table 4. What are some potential causes for error?

$$\%Error = \frac{|K_{Experiment} - K_{Manufacturer}|}{K_{Manufacturer}} \times 100 \qquad \text{eq.(3)}$$

Table 4 - Percent Error between Experimental Stiffness and Manufacturers Specifications

	Two-Point Stiffness	Average Stiffness
Spring 1		
Spring 2		

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