

### Purpose

1. Compare the spring constants of 2 rubber bands in series with 2 rubber bands in parallel.
2. Use iSENSE software to analyze a scatter plot and create a line of best fit for data.

### Materials

1. Stable stand or other apparatus to hang weights.
2. 2 stout rubber bands.
3. Set of hanging weights.
4. One of meter stick (precision 1 cm)
5. Computer or tablet with internet connection
6. Interactive website – [www.isenseproject.org](http://www.isenseproject.org)



### Pre-Lab

1. Review your data/results from the previous lab: *Rubber Band Spring Constant*. Pay particular attention to the spring constant of your data and the spring constant of the class average data.
2. You will be assigned to analyze the spring constant of *either* 2 rubber bands in series or 2 rubber bands in parallel.
3. Answer the following questions on a separate sheet of paper in 1-2 complete sentences.
  - a. Do you think the spring constant for 2 rubber bands in series will be less than, equal to, or greater than the spring constant of a single rubber band? Why?
  - b. Do you think the spring constant for 2 rubber bands in parallel will be less than, equal to, or greater than the spring constant of a single rubber band? Why?

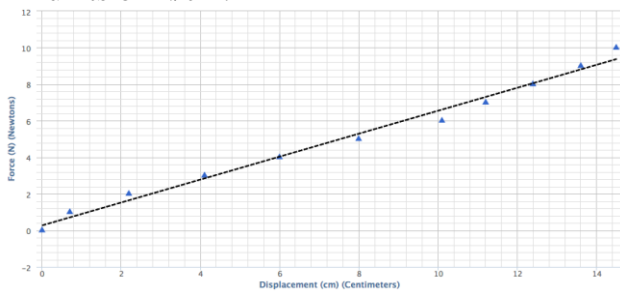
### Methods

1. Loop 2 rubber bands together so they are connected, and hang them from the stand in either series or parallel formation. Loop the hook of the weight hanger through the rubber band. Use the meter stick to record the height of the bottom of the hanger from the base in centimeters.
2. Set up your data in iSENSE
  - Go to [www.isenseproject.org](http://www.isenseproject.org)
  - Click on *Projects*.
  - Search for and select *Spring Constants of Serial and Parallel Rubber Bands*.
  - Enter your contributor key (see the whiteboard) and your last name (i.e. Richter) in the *Contribute Data* fields. Click *Submit Key*.
  - Click on *Manual Entry* under *Contribute Data*.
  - Enter the data set name as your last name and the current time (i.e. Richter 8:21)
  - Click “Add Row” until you have 11 rows for your data.
  - In the first line of your data, enter 0 for “Displacement” and 0 for “Force”.
3. Add 1 Newton (N) of weight to your hanger (100g  $\approx$  1 N). Measure the displacement (**change** in height of hanger). Enter your new data in the next row.
4. Select the appropriate option (Series or Parallel) from the “Configuration” dropdown menu.
5. Repeat steps 3-4 until you reach a weight of 10 N. Then click “Save”.

### iSENSE Analysis

1. In your scatter plot, select the “Displacement” button for the x-axis and the “Force” button for the y-axis.
2. Under analysis tools (scroll down) click “Draw Best Fit Line”.

3. Mouse over the best fit line and note the coefficient of x, which is the slope of the line. This value is your spring constant in units of N/cm.



4. Take a screenshot of your graph, like the one above, and save it as a picture file named YourLastName –Series or YourLastName - Parallel (i.e. Richter – Series).
5. Return to the home screen of the project and click “Visualize”. Your new visualization screen should now show the class set of data. Reselect the settings from Step 1.
6. From the “Group By” dropdown menu, choose “Configuration”.
7. Check only the “Series” box. Then use the Analysis Tools to draw a line of best fit. Record the slope of the line. This is the spring constant for the class average of 2 rubber bands in series.
8. Repeat step 7 with the “Parallel” box.

### Discussion Questions

Compose an email to your teacher with the subject YourLastName –Series vs Parallel (i.e. Richter – Series vs Parallel)

1. Attach your visualization to the email.

Answer the questions below in **2-3 complete sentences**.

2. What is the spring constant of your 2 rubber bands (in series or parallel)? How do you know?
3. How does your spring constant with 2 rubber bands compare to your spring constant with only a single rubber band from the previous lab?
4. Examine the visualization for the class set of data. Compare the spring constant of 2 rubber bands in series to 2 rubber bands in parallel. Include the values of the spring constants in your response.
5. Based on your current data, predict the spring constant for 3 rubber bands in series and 3 rubber bands in parallel. Justify your predictions.
6. What could you change about the materials or the procedure of this experiment to increase your understanding of spring constants for your next experiment?
7. EXTENSION: Predict the spring constant for 2 rubber bands in parallel attached to 1 rubber band in series. Justify your prediction.