HOOKE'S LAW EXPERIMENT

Virtual Lab Guide

Force-Extension Graph • Spring Constant • Series & Parallel Extensions

Student Name	Date	Class / Section

I. Objective

To investigate the relationship between force and extension for a spring, plot a Hooke's law graph, determine the spring constant k, and extend the investigation to springs in series and parallel.

II. Virtual Apparatus & Setup

Virtual Lab: www.senpaicorner.com/hookes-law-experiment
Use the on-screen spring, slotted masses, movable ruler, results table and graphing tool. The Guide Me mode can walk you through the core single-spring investigation.

III. Variables

Variable	For the core experiment
Independent	Applied force, F
Dependent	Extension, x
Control	Spring type and spring arrangement

IV. Activity 1: Core Hooke's Law Experiment

1. Select the Medium spring and choose Single spring for the arrangement.
2. With no mass attached, align the ruler vertically so its 0 cm mark is level with the top clamp. Record the unloaded spring length.
3. Drag a slotted mass onto the hook. Let the motion settle, or click Stop Oscillation before taking a reading.
4. Align the ruler correctly and click Record current reading to log the mass, force and extension.
5. Repeat for at least five different loads, using gradual increases and keeping the core data within the linear region.
6. Use the simulator results table to check your recorded values, then copy the data into the table below.
7. When you have enough readings, choose Force (N) vs. Extension (cm) and click Plot Graph.
8. Complete the graph analysis on Page 2.

Results Table

Mass / g	Force / N	Spring length / cm	Extension / cm
0	0		0

THE HOOKE'S LAW GRAPH

Activity 2: Plot, analyse and determine the spring constant

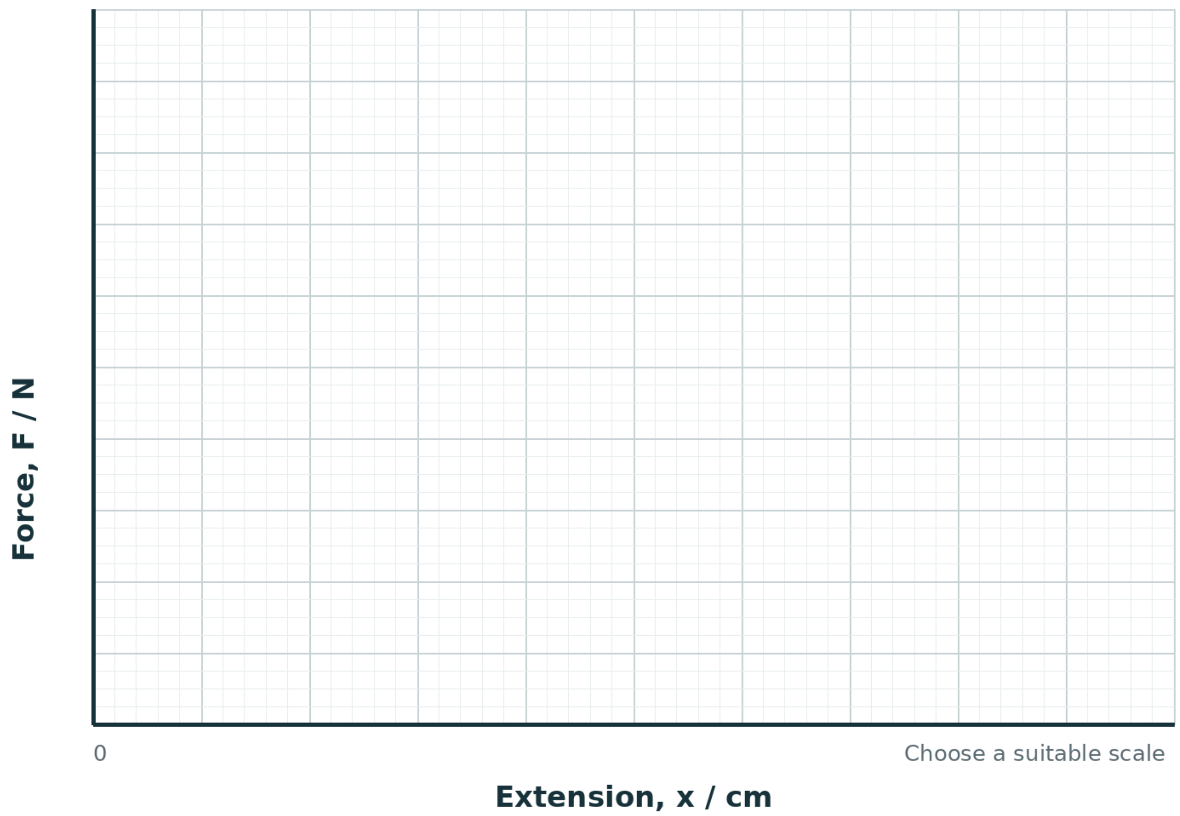
$$F = kx$$

For a Force vs Extension graph, gradient = k

For the standard Hooke's law graph, plot Force, F, on the vertical axis against Extension, x, on the horizontal axis. Use the straight-line region to determine the spring constant.

- Transfer your measured force and extension values from Page 1.
- Choose a suitable scale that uses most of the graph area.
- Plot each point accurately and draw a line of best fit through the linear region.
- Find the gradient using two well-separated points on the best-fit line, not two raw data points.
- Compare your calculated k with the value reported by the simulator.

Blank Hooke's Law Graph



Gradient working	Spring constant
ΔF = __________ N	k = gradient = __________ N/m
Δx = __________ cm	Simulator k = __________ N/m

Graph Analysis

1. What does the gradient of your Force vs Extension graph represent?

2. What evidence from your graph shows that the spring obeys Hooke's law in the linear region?

3. If the graph begins to curve, why should those points not be used to calculate the original spring constant?

ANALYSIS, EVALUATION & CONCLUSION

Experimental technique

For reliable readings, let the spring reach equilibrium before measuring. The simulator only shows a correct length reading when the ruler is straight, close to the spring, and its 0 cm mark is aligned with the fixed top clamp.

V. Analysis & Discussion Questions

1. Why should the spring be allowed to stop oscillating before a length reading is taken?

2. Why must the ruler be vertical and correctly aligned with the top clamp?

3. What happens to the force-extension graph after the limit of proportionality?

4. How is the limit of proportionality different from the elastic limit?

5. Why is it better to add load in small steps when investigating a spring?

6. State one way you could improve the reliability of a physical version of this experiment.

Optional exploration

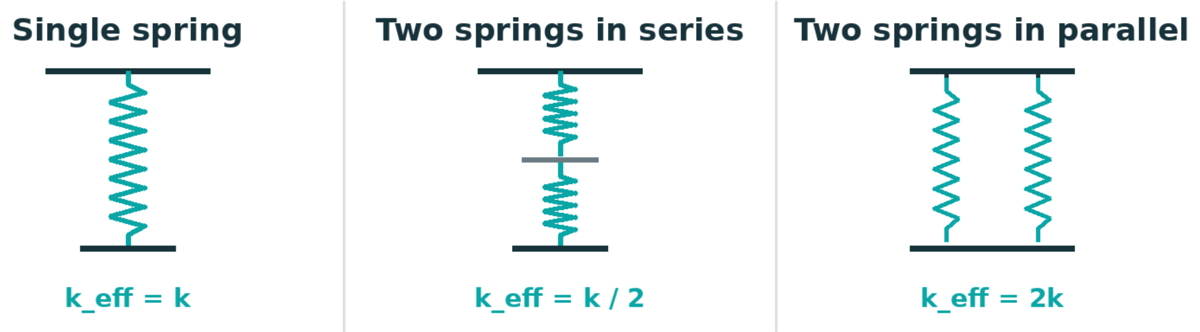
After completing the core experiment, you may switch off Guide Me and deliberately explore larger loads. The simulation can show non-linear behaviour, permanent stretch beyond the elastic limit, and spring failure. Keep these overload readings separate from the data used to calculate the original k.

VI. Conclusion

Summarise the relationship between force and extension, state the spring constant you obtained, and describe what your Hooke's law graph shows.

EXTENSION INVESTIGATION

Springs in Series and Parallel



Key idea
For two identical springs: series gives the same force through both springs and their extensions add, so k_eff = k/2. In parallel, both springs have the same extension and share the load, so k_eff = 2k.

VII. Activity 3: Compare Spring Configurations

Prediction

1. Which arrangement do you predict will extend the most under the same applied force?

2. Which arrangement should produce the steepest Hooke's law graph? Explain your prediction.

Method

1. Choose one base spring and keep the spring type the same for all three trials.
2. Collect at least four linear-region readings for Single spring, Two identical springs in series, and Two identical springs in parallel.
3. For each arrangement, plot Force vs Extension and determine the effective spring constant from the gradient.
4. Compare your experimental k_eff values with the expected relationships shown above.

Comparison Table

Arrangement	Measured k_eff / $N\ m^{-1}$	Expected relation	Extension for same force	Graph gradient
Single		k		
Series		k / 2		
Parallel		2k		

Discussion

3. Did your measured k_eff values follow the predicted series and parallel relationships?

4. Explain why series springs produce a smaller graph gradient while parallel springs produce a larger graph gradient.

MYSTERY SPRING CHALLENGE

Use the experiment and graph to discover an unknown spring constant

Challenge aim

Select the Mystery spring, collect your own data, and determine its spring constant without being given k. Then test whether the same spring follows the expected series and parallel relationships.

VIII. Activity 4: Determine the Mystery Spring Constant

1. Select Mystery spring and begin with the Single spring arrangement.
2. Use small loads and collect at least five readings in the straight-line region.
3. Plot a Force vs Extension graph and calculate k from the gradient.
4. Record the quality of the fit shown by the simulator if available.
5. Estimate where the force-extension relationship begins to deviate from a straight line.
6. Repeat the investigation with the Mystery spring in series and parallel, then compare the measured k_eff values with your predictions.

Mystery Spring Results

Quantity	Your result
Single-spring k	________________ N/m
Straight-line fit, R^2	________________
Approx. proportionality limit	________________ N
Predicted series k_eff	________________ N/m
Measured series k_eff	________________ N/m
Predicted parallel k_eff / Measured parallel k_eff	__________ / __________ N/m

Challenge Questions

1. How did you determine the mystery spring constant from your data?

2. How confident are you in your value of k? Use your graph or fit quality to justify your answer.

3. Did the mystery spring still follow the expected k/2 and 2k relationships in series and parallel?

IX. Final Reflection

In one or two sentences, explain how the Hooke's law experiment and Hooke's law graph together allow you to compare different springs and spring arrangements.

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