Lab 9: Measuring a Spring Constant

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Objectives

This lab activity measured the spring constant of a spring using four methods: displacement of the spring with added mass, characteristics of oscillatory motion with added mass, and displacements of the spring in series and parallel with another with added mass.

Theory

A force applied to a spring causes the spring to stretch or compress. How it stretches with force depends on the spring's spring constant, k, a relation between force F applied and displacement from equilibrium position Δs:

$$\sum \vec{F}_s = -k\Delta s$$

When finding the spring constant through mass m loaded onto the spring and its period T in simple harmonic motion, the following equation can be used:

$$k = \frac{4\pi^2 m}{T^2}$$

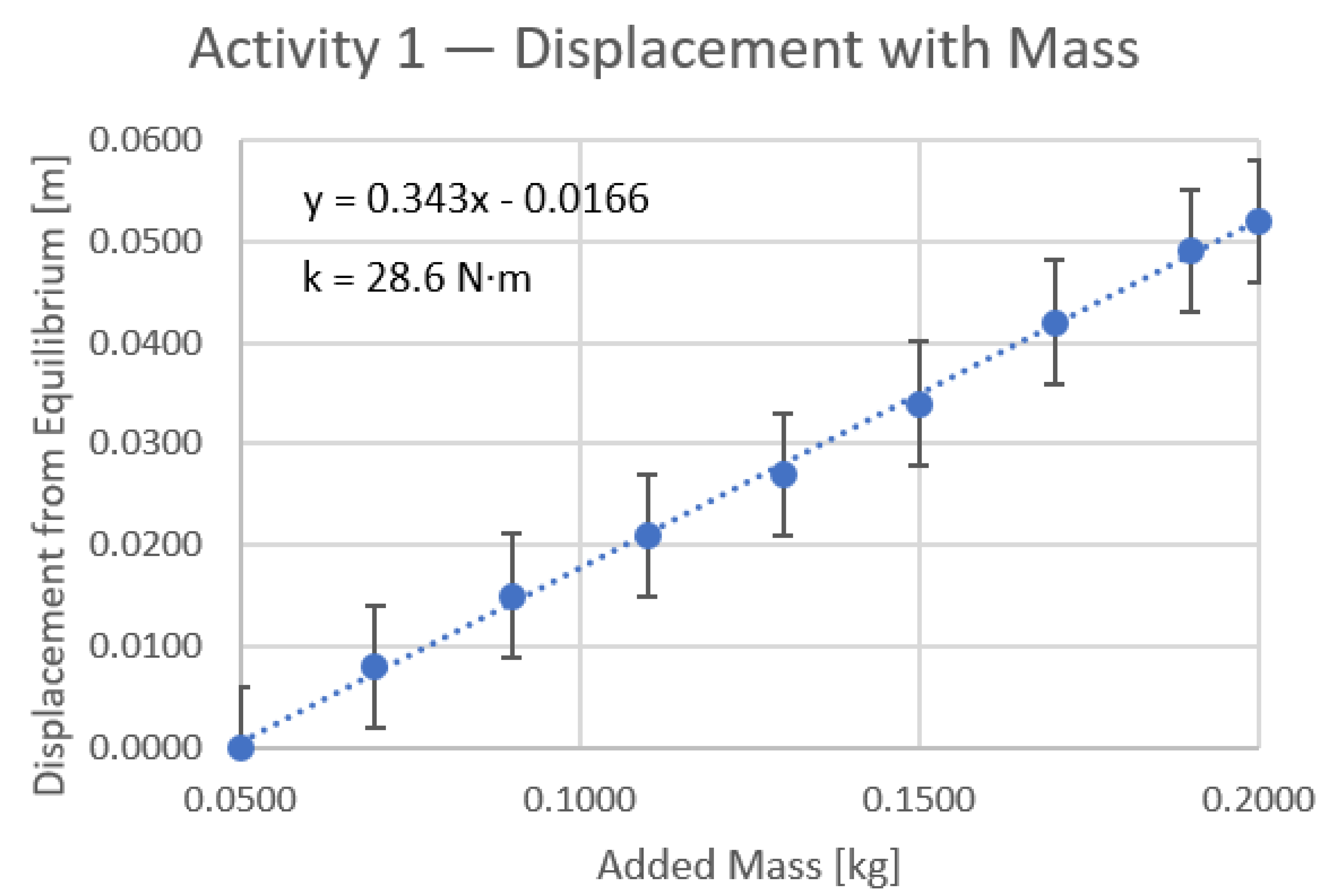
When springs are put into parallel with each other, as with capacitance in capacitors, their spring constants sum:

$$k_{parallel} = k_1 + k_2$$

When added inline (in series), their spring constants combine as follows:

$$k_{series} = \left(\frac{1}{k_1} + \frac{1}{k_2}\right)^{-1}$$

Observations and Data



Activity 2 – Period of Oscillatory Motion

Mass (all ± 0.1%) [kg]	Period [s]	Spring Constant (k) [N*m]
0.150	0.466 ± 0.023	27.3 ± 2.7
0.170	0.494 ± 0.023	27.5 ± 2.5
0.190	0.527 ± 0.023	27.0 ± 2.3
0.210	0.551 ± 0.023	27.3 ± 2.3
0.230	0.578 ± 0.023	27.1 ± 2.2
	k_{best}	27.2 ± 5.4

Activities 3 and 4 – Springs in Parallel and Series

	Spring Constant k [N*m]
Activity 1 Value – Individual	**28.6 ± 0.4**
Other Team's Activity 1 Value – Individual	29.0 ± 0.4
Theoretical Activity 3 Value – Combination	57.6 ± 0.6
Actual Activity 3 Value – Combination	48.4 ± 0.6
Actual Activity 3 Value – Individual	19.4 ± 0.7
Theoretical Activity 4 Value – Combination	13.2 ± 0.6
Actual Activity 4 Value – Combination	14.4 ± 0.6
Actual Activity 4 Value – Individual	24.3 ± 0.7

Methodology

In Activity 1, the change in displacement of the hanging spring was measured as mass (thus more downward force) was added. To derive the spring constant, gravitational acceleration g (9.8 m/s^2) was divided by the slope in the graph to the top right.

In Activity 2, the hanging spring was displaced by about a centimeter from its equilibrium position with different masses loaded onto the spring. Its period was measured (by timing for 15 oscillations and dividing) and with the mass loaded the spring constant could be calculated.

Activities 3 and 4 were conducted with hanging mass and displacement like in Activity 1, only with two springs instead of one. In Activity 3 they were hung in parallel and in Activity 4 they were hung in series. Using the equations on the left and a given value for one of the springs, the spring constant of the other spring could be calculated.

Conclusion

Spring constants from Activities 1 and 2 are consistent with each other, along with Activities 2 and 4. However, Activity 3 was consistent with no other activity which raises concern about the methodology of the experiment.