January 15th, 2024
PHYS 159 LAB 1

Measure the Spring Constant of a Spring

Objective: Measure the spring constant of a spring

Clarify the Objective:

Think: The spring constant k is a measure of a spring's stiffness, indicating how much force is needed to stretch or compress it. Higher k values signify stiffer springs.

Pair: My partner and I came to the same conclusions

Share: Ratio of amount of force required to compress and expand a spring from its resting length (Newtons per Meter)
Hooke's law: F=-kx (only valid for small to medium rarefactions)

Explore Tools:

Tool	Physical Parameter	Resolution	Range	Usage
Meter Stick	Length	1mm	1m	Measuring compression of a spring
Calliper	Length	0.05mm	155mm	Specific measurements
Scale	~~Mass~~ Edit 1: Force (hand push or object on top)	1gram	5kg	Calculate force
Edit 1: Adding tool to use for measurements Phone (acting as weight) Edit 2:	Mass	N/A	~~246gram ± 0.5 gram (mass of phone)~~ 220grams ± 0.5 gram (mass of phone)	~~Aid in calculating spring constant using mass of the phone~~ Aid in calculating

changing to use meter stick				spring constant using mass of the meter stick

	Weight	Length
Spring	82grams $\pm$ 0.5 gram	~~125.25mm $\pm$ 0.5mm~~ Edit 1: Found out tick is 0.05mm not each number 125.50mm $\pm$ 0.5mm

125 + 10*0.05

Relate Quantities:
Think: Since $F = k\Delta x$ (got rid of the negative since it just a courtesy for the opposite direction that it acts in)

$$k = \frac{\Delta F}{\Delta x} = \frac{g(m2-m1)}{x2-x1}$$

Take a ruler and weigh it on the scale for the mass value in the equation. Then once we but this mass on top of the scale we will be able to calculate the Δx of the scale. After this we will be able to figure out the spring constant value.

while g is a constant and shouldnt have any uncertainty we still aren't exactly sure how g was calibrated as this can vary across the globe

Pair: Leo clarified how to measure the different variables missing using the different tools we were given. Also helped create the following equation for uncertainty:

$$\frac{\Delta k}{k} = \sqrt{\left(\frac{\Delta m}{m}\right)^2 + \left(\frac{\Delta x}{x}\right)^2}$$

Edit 1: changed formula to correct for “delta”

Edit 2: change formula to add constant “g” which effects the uncertainty

$$\frac{\delta k}{k} = \sqrt{\left(g\frac{\delta m}{m}\right)^2 + \left(\frac{\delta x}{x}\right)^2}$$

Share: Spring constant relates to the change in force and how to determine their uncertainties

Approaches to Measure Different Values

Think: By placing the mass of the ruler on the spring we are able to calculate how much the spring compresses by and therefore we are able to find delta x. We are also able to measure mass of the spring and ruler combined.
Using this we are able to calculate spring constant by plugging these values back into the formula.

Pair: Leo had the same idea as i did

Share: We can also use hands to create a force however my groupmate and I decided against this because of human error. It’s impossible to make sure you are applying the same force consistently

Another way to do it is to calculate it using harmonic oscillations however there is no way to make this controlled with our equipment provided so we are advised against it.

Data Recording

	X1	X2	M1	M2
Data	125.50mm $\pm$ 0.5mm	101.50mm $\pm$ 0.5mm	82grams $\pm$ 0.5 gram	301grams $\pm$ 0.5 gram

For the uncertainty of X2. While our TA and instructor mentioned that we should take the range of values the spring was fluctuating between and divide it by four to get a more accurate uncertainty, our set up did not experience any fluctuation and the scale read the same force consistently.

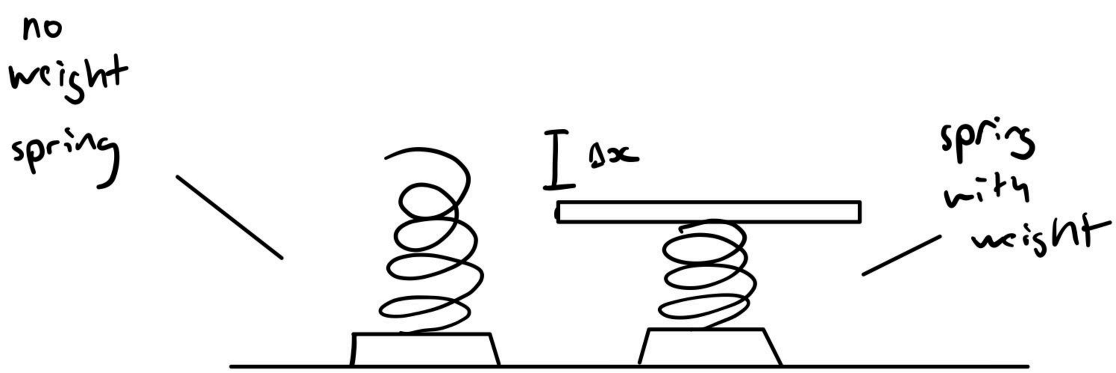
Calculations

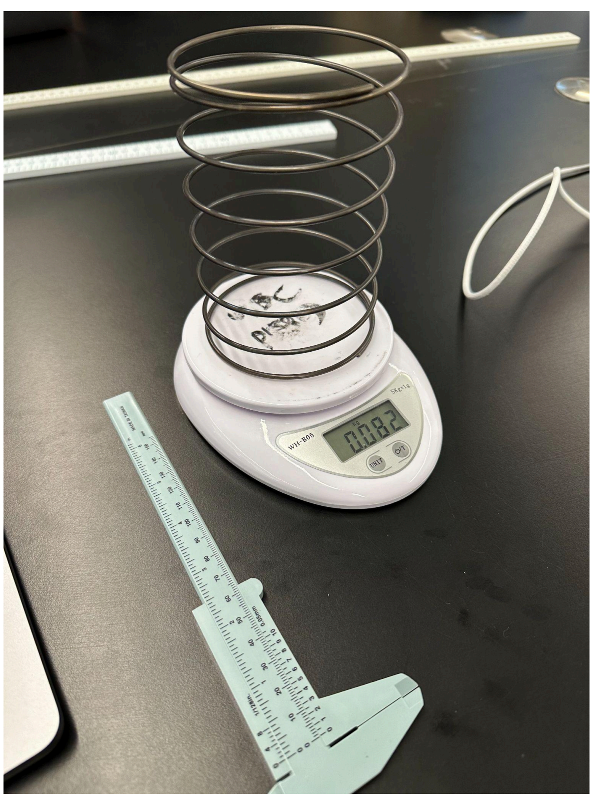
Calculation of spring constant value k:

k = (301 - 82) * 9.81 * 10-3 / (125.50 – 101.50) * 10-3 = 89.5 N/m

Calculation of uncertainty of spring constant $\Delta k/k$:
δm = sqrt(0.5^2 + 0.5^2) = sqrt(0.5)
δx = sqrt(0.5^2 + 0.5^2) = sqrt(0.5)
δF = g * δx / Δm= 9.81 * sqrt(0.5) / (301 - 82) = 0.03167
δk = k * sqrt(δF ^2 + δx^2 / Δm) = 3.87 N/m

Apparatus





Since we were on a time crunch we were unable to get data ourselves by using a lighter weight to apply a force onto the spring. However, we were able to source data from other groups with regards to this alternate method (Jordyn and Ella). All in all I think we can say that our method where we use a heavier mass of an object to measure the spring constant is better. This is because using a heavier mass causes a larger displacement of the spring and therefore creates less of an uncertainty.

Final Procedure

1. Secure the spring vertically so that it can be extended or compressed without hindrance. (see figures above)
2. Position the meter stick alongside the spring for measuring displacement.
3. Ensure the scale is calibrated and ready for use.
4. Record the initial length of the spring X1 without any load.
5. Place the standard mass (e.g., the phone) on top of the spring.
6. Measure the new length of the spring X2 under the load.
7. Record the mass of the standard object M2.
8. Calculate the change in length Delta X.
9. Use the formula where $k = \frac{\Delta F}{\Delta x} = \frac{g(m2-m1)}{x2-x1}$ g is the acceleration due to gravity 9.81 m/s², M1 is the mass of the spring (if significant), and M_2 is the mass of the object. Note: g is considered constant, but its calibration may vary slightly.
10. Calculate the uncertainty in k using the formula $\frac{\delta k}{k} = \sqrt{\left(g\frac{\delta m}{m}\right)^2 + \left(\frac{\delta x}{x}\right)^2}$
11. Record all measurements in a table format, including uncertainties.
12. Ensure all measurements are consistent and repeated if necessary for accuracy.
13. Analyze the data to determine the spring constant.
14. Reflect on the accuracy of the method and any potential sources of error.