Formal Lab

Hooke's Law

Physics 4A

Connor Darling

Lab Partner: Gabe Ilano

December 2022

Chapter 1

Purpose

To verify Hooke's law and calculate the spring constant.

Chapter 2

Theory

The force due to a spring stretched (or compressed) a distance Δx from the equilibrium position is given by the following expression:

$$\vec{F_s} = -k\Delta\vec{x}$$

where s = (force exerted by) spring
k = the spring constant (in N/m)

Chapter 3

Procedure

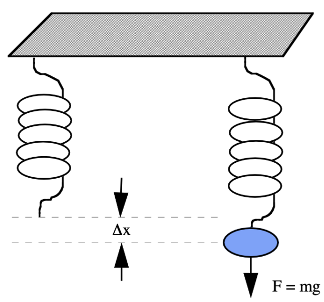
3.1 Procedure Equipment

The necessary equipment for this lab is as follows:

- Meter Stick
- Spring
- Weights
- Clamp
- Rods
- Suspension Clamp

3.2 Position Measurements

- The equipment is to be set up as shown below:



- Hang a weight from the end of the spring. For the long spring use weights ranging from 0.5 kg to 2 kg and for the short spring use weights ranging from 2 kg to 4 kg. Make sure you do not select too heavy of a weight or the spring will permanently stretch.
- Measure the distance (Δx) the spring is stretched from its equilibrium position ($x = 0$).
- Repeat the above measurement for at least 7 more weights.

Chapter 4

Data

Data Collected					
Configuration of Mass	Mass in kg	Uncertainty $+-$ in kg to due scale	x_i in meters	x_f in meters	Uncertainty $+-$ in meters due to meter stick
#1	1.036	0.0005	0.782	0.784	0.0005
#2	2.033	0.0005	0.782	0.803	0.0005
#3	4.033	0.0005	0.782	0.876	0.0005
#4	6.032	0.0005	0.782	0.951	0.0005
#5	1.528	0.0005	0.782	0.786	0.0005
#6	3.527	0.0005	0.782	0.860	0.0005
#7	5.526	0.0005	0.782	0.933	0.0005
#8	2.530	0.0005	0.782	0.822	0.0005

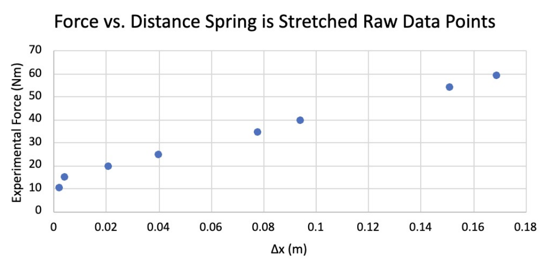
Chapter 5

Analysis

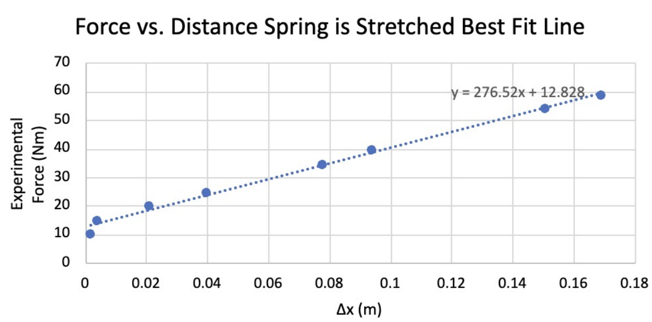
1. For each weight, calculate the force ($F = mg, g = 9.8\frac{m}{s^2}$) exerted on the spring by the Earth's gravitational force.

Force Calculated for each Configuration of Mass & Δx		
Configuration of Mass	Experimental F in Nm	Δx in meters
#1	10.153	0.002
#2	19.923	0.021
#3	39.523	0.094
#4	59.114	0.169
#5	14.974	0.004
#6	34.565	0.078
#7	54.155	0.151
#8	24.794	0.040

2. Plot the force F versus the distance the spring is stretched (Δx). Based on Hooke's law your graph should follow a straight line.



3. Draw a best-fit line between the points and calculate the slope of the line. The slope of the line will correspond to the spring constant k_{exp}.



Using this graph, the spring constant $k_{exp} = 276.52$ N/m.

Chapter 6

Error Analysis and Procedural Errors

6.1 Front-End Error - RSS

For RSS, the greatest contributors are used. The greatest contributors are the lowest weighing mass configuration in kg, and the initial position of the spring in m.

$$RSS = \sqrt{\left(\frac{0.0005m}{0.782m}\right)^2 + \left(\frac{0.0005kg}{1.036kg}\right)^2} \times 100\% = 0.08\%\ (0.080\%)$$

6.2 Back-End Error

Percent difference was employed on this experiment because the experimental value was being compared with a known actual value. The goal of the experiment was to compare (or get the difference) between the two values. In general the experimental spring constant k_{exp} was close to the acutal spring constant value.

$$\%\text{difference} = \frac{|E_1 - E_2|}{\frac{E_1+E_2}{2}} \times 100\% = \frac{|276.52 - 278|}{\frac{276.52+278}{2}} \times 100\% = 0.53\%\ (0.534\%)$$

6.3 Potential Cause of Error

There are a number of potential causes to the error presented in this lab experiment. The two most notable causes of error are as follows:

- Miscalculated height - although we were aiming for within $0.0005m$ each time we measured the length the spring stretched, there is a possibility that this preciseness was not met for all eight configurations of mass. Additionally, it is also possible that the tabel our experiment took place on was not level, clouding an accurate measurement within $0.0005m$.
- Scale limitations - the scale weighing mechanism is only accurate a few decimal places.

6.4 Error Analysis Questions

- Compare your experimental value(s) of k_{exp} with the actual value(s) of k for your spring. (Spring k is 278 N/m.)

  The actual constant value of the spring is 278 N/m.
  The experimental value of the spring is 276.52 N/m.
  The difference between the two values is 1.48 N/m.

- Do your results agree with Hooke's law (i.e. is F directly proportional to x)?

  The results obtained from the experiment were not exact, but are close enough to to agree with Hooke's law.

Chapter 7

Conclusion

In conclusion, the purpose of this lab was to measure an experimental spring constant k_{exp} and compare it with the actual value of 278 N/m. This was to be done by attaching a hanging spring and measuing the x_i value of it. Then, attaching 8 different configurations of that weight to the spring and measure the x_f value. After finding the Δx, the force F in Nm could be found. Once the force F was calculated, it could be plotted versus the Δx, and the slope of a best fit line was used to find the experimental k_{exp}.

Following this process, the k_{exp} ended up being 276.52 N/m. Though this is not eaxctly 278 N/m, the error allowed, could account for this deviation from the actual value. The RSS error using greastest contributors ending up as 0.08%.

Furthermore, the backend error implementing %difference was 0.53%.

Considering the purpose of the lab, the result, and factors of possible error; the goal of this lab was accomplished.

Chapter 8

Suggestions for Improvement

Due to the age and simplicity of this lab, the professors of the Saddleback College Physics department have implemented almost all of the improvements that could be made to this lab.

Despite this, if I were to improve the lab in any way, it would be to provide a much more indepth procedure section with an elaborate section on apparatus set up. With that, clear instructions of where and how to measure should be made. If I did not have access to an example of my professors apparatus set up, I do not think my error would be as minimal as it was. Furthermore, without the guidence of my professor, I would have taken incorrect measurements due to the lack of clarity when it comes to the measurement in the procedure.