LAB 7. SPRINGS

Introduction

External force applied to an object will change the object's size or shape or both. Whether the object springs back to its original shape after the force is removed or remains deformed depends on the arrangement and bonding of the atoms in the material as well as the magnitude, rate and duration of force applied. The simplest approximation to the behavior of a spring is Hooke's law, $F = -kx$, where F is the force exerted by the spring, k is the stiffness of the spring, and x is its distortion from its equilibrium size.

In this lab, you will determine if Hooke's law adequately models the behavior of several springs.

Lab activity

Supplies

springs, several weights, meter stick, rod and table clamp

Procedure

1. Measure and record the initial length l_0 of the spring.
2. How accurate do you believe your measurement is? (Is the base of the meter stick in the right place? Is the meter stick right next to what you are measuring, or is there a parallax? Are there any other factors that might degrade the reliability of your measurement?) Record an estimate of your uncertainty in the measurement as a "±".
3. Hang a known mass from the spring and record the spring's length l_1.
4. How confident are you in the value of the "known" mass? Record an estimate of your uncertainty in the value as a "±".
5. Add more known masses incrementally until you have seven (7) measurements l_1–l_7 in addition to the starting length. Record these additional data, and their uncertainties, as well.
6. Convert the masses to the forces they exert on the spring by multiplying by the gravitational field g. In other words, $F = mg$. Record these forces.
7. How confident can you be in the forces you calculated? (What factors might affect the validity of your result?)
8. Repeat the process with three other springs, for a total of four springs.

Data Processing

1. For each spring, plot a graph of length vs. cumulative load (force, not mass).
2. Fit straight lines ($y = mx + b$) to your plot. Record the parameters m and b for each plot.
3. What is the physical meaning of the fit parameters m and b?
4. For each spring, find the predicted value of spring length l_c from the straight-line fit for each load. Calculate the residuals $\sigma_i = l_{ci} - l_i$.

5. Make plots of the residuals vs. load.
6. Compare the residuals σ with the estimated uncertainties in l.
7. For each spring, estimate the spring constant k.

Lab report

Show the raw data, including your uncertainty estimates, and the graphs (l vs. F and σ vs. F) that you made. Answer the following questions.

- How did you determine your uncertainty estimates for the spring lengths?
- How did you determine your uncertainty estimates for the hanging masses?
- Does the model appear to adequately describe the data? What is your evidence?
- What effects or influences might cause the data to diverge from the model?
- What is your estimate of the spring constant k of each spring you studied? How did you determine this estimate?