DO SPRINGS IN THE REAL WORLD OBEY THE BOOK?

Introduction

Is the simplified model your textbook presents for springs exactly adequate for describing the behavior of real world springs or is it only part of the story? In this lab, you will do some experiments to try to identify shortcomings (if there are any) of the theory presented in the book about springs. The main questions to focus on are:

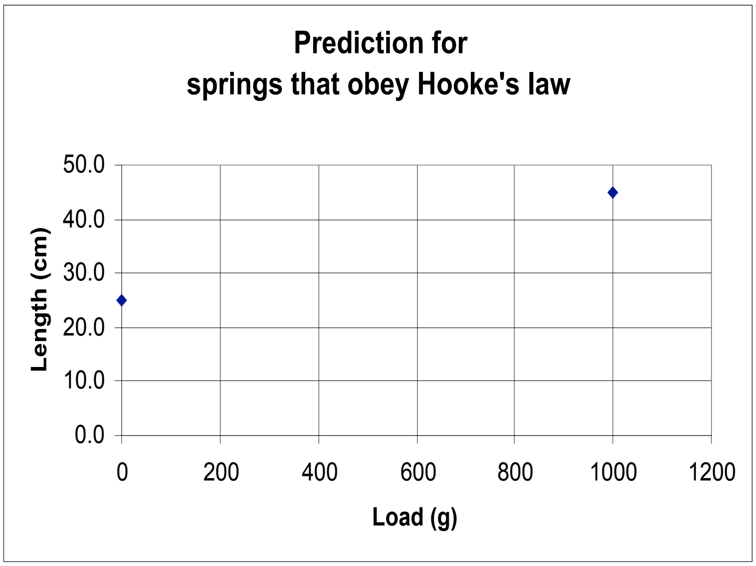
- Do real world springs obey Hooke's law? (Hooke's law claims that $\vec{F} = -k\vec{x}$ for springs)
- Does a mass on the end of a spring really move in simple harmonic motion with a period given by the formula in the book?

Before you can answer these questions, it is essential that you be able to use the theory correctly to construct detailed predictions that can be tested against real world observations. The purpose of the two prelab questions is to guide you through the process of making predictions based on theory. Instructions for the lab follow the prelab questions.

Prelab question for Part 1:

In the first part of the lab, you will test whether real world springs obey Hooke's law. You will hang different masses from the spring and record how the length changes. The following problem will help you make a detailed prediction of what *would happen* in this part of the lab *if* real world springs obey Hooke's law.

Spring A is known to obey Hooke's law. Spring A has a length of 25.0 cm when nothing is suspended from it. (This "no load" length is often called the relaxed length). When a load of 1000 g is suspended from the spring, spring A stretches out to 45.0 cm. This information is shown below:



Load (g)	Length (cm)
0	25.0
100	
200	
300	
400	
500	
600	
700	
800	
900	
1000	45.0

a) Use Hooke's law to predict how long will Spring A be if a load of 500 g is suspended from it. Explain how you used Hooke's law to get your answer.

b) Fill in the remainder of the chart and complete the graph using Hooke's law.

c) Use the graph to determine the spring constant k of spring A. Explain how you used the graph to determine k. (Note: Make sure your units are correct. Your spring constant should have units of N/m.)

d) Check your understanding: Spring B (which also obeys Hooke's law) is twice as stiff as Spring A. Spring B has a relaxed length of 15.0 cm. Sketch the curve for Spring B on the graph above. Explain how you determined your answer.

Prelab question for Part 2:

In the first part of the lab, you will test whether a mass bobbing up and down at the end of a spring behaves exactly as the text predicts it should. The following problem will help you make some specific predictions about what *would happen* in this part of the lab *if* the information your book presents about is completely correct.

Spring C obeys Hooke's law with a spring constant of 50 N/m.

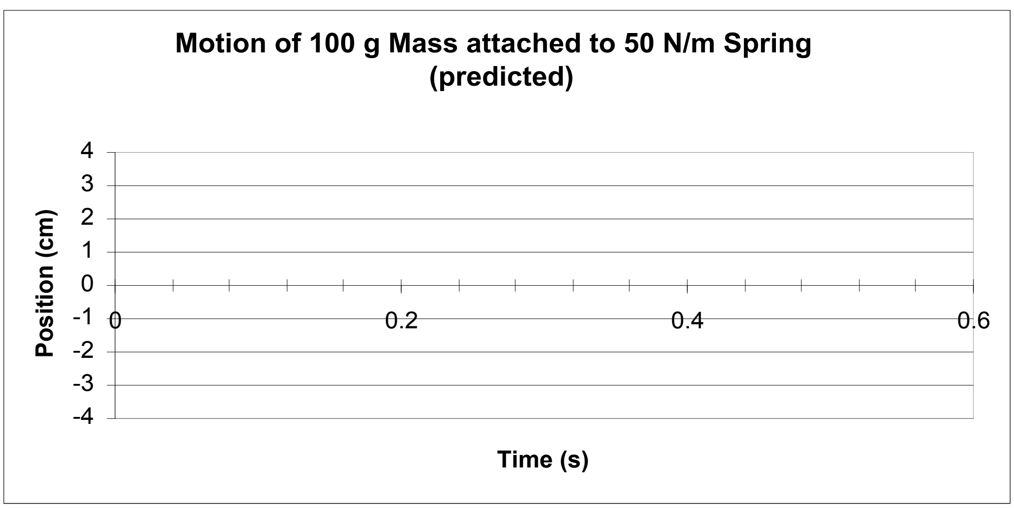
a) A 100 g mass is suspended from Spring C. The mass hangs at rest. The mass is pulled down 3.0 cm and released. How long will it take the mass to complete one full cycle of motion?

b) The same experiment as in a) is repeated. This time the mass is pulled down 6.0 cm and released. How long will it take the mass to complete one full cycle of motion? Explain your answer.

c) The 100 g mass is replaced with a 400 g mass. The mass is pulled down 3.0 cm and released. How long does one full cycle take now? Compare your answer to question a). What would the period be if the mass were 900 g? Explain.

d) Fill in the following "rule of thumb": If the mass increases by a factor of N, the period increases by a factor of ______.

e) Draw a graph of the mass's position versus time for the experiment described in part a) on the axes below. For your graph, choose your coordinates so that, at the time the mass is released, $x = -3.0$ cm at $t = 0$.



Lab Instructions

Equpiment/Safety Issues

Do not overstretch springs! Springs can fail suddenly if they are overstretched. If the spring fails, it will no longer support the load attached to it.

Instructions for Part 1:

Take data to see if your spring obeys Hooke's law. Some hints/suggestions:

- Decide how you will measure the length of the spring (i.e. from where to where on the spring) and record your choice in your lab notebook. (It doesn't matter exactly how you do the measurement. What's important is that your method is consistent and that you keep a record of how the measurement was done).
- A graph with as few as seven or eight points (provided they are carefully chosen) can show you any key differences that might exist between the shape of the graph for real world springs and your prediction from the prelab.
- Use Excel to create the graph. (You may even want to enter the data directly into Excel, so you can watch the graph emerge as you take data).
- Take data over as wide a range of masses as possible.

Analyze your data:

- Compare the data from the real world spring with your prediction. How is your data similar to your prediction? How does it differ?
- Compare your results of at least one other lab group.
- Determine the spring constant for your spring.

Make some conclusions:

- Summarize the differences and similarities between Hooke's law and the behavior of real springs.
- Speculate about the cause of the observed differences.

Instructions for Part 2:

In the first part of the lab, you will test whether a mass bobbing up and down at the end of a spring behaves exactly as the text predicts.

Take data to see if the rule of thumb you predicted in the prelab holds for these springs. Some hints/suggestions:

- Use the same spring as in part 1), since you now know the *k* value for that spring.
- Decide how you will measure the period. Try to get the best measurement possible. Record how you measured the period in your notebook.
- If there are discrepancies between your prediction and your data, you will need to determine whether the difference can be explained away by inconsistent measurements or not. Make sure you take multiple measurements.

Take data to test your prediction about the position versus time graph.

Analyze your data.

- Compare your data to the rule of thumb you made in the prediction. Can the discrepancies be explained by inconsistent timing? Explain.
- Test your data to see if it supports the formula for period given in the text. (Use the *k* value you determined in part one of the lab). Does the formula work better for some masses than others? If so, is there a trend?
- Compare the real position versus time graph to your prediction. (There will be two lab stations with motion sensors). Note similarities and differences.

Make some conclusions:

- Summarize the differences and similarities between the predictions and the behavior of real springs.
- Speculate about the cause of the observed differences.