ESBA 02: Spring Constants and Spring Energy Calculations

In Class Activity: 11/10/2014
Worksheet Due Date: 11/12/2014

Student Name:______________________

Student Name:______________________

Student Name:______________________

Student Name:______________________

This engineering skill building activity (ESBA) will take place during class on Monday, 11/10/2014. **To earn credit for this assignment, you must be present in class, actively engage in the entire activity, and submit (with your team) this completed worksheet.** Once your team has completed all 4 of the activities in this ESBA, submit the physical copy of this completed worksheet (i.e., do not submit this via blackboard). Each *team* only needs to submit one completed worksheet. You can submit the completed worksheet in class today, or, if you aren't able to finish all the activities, you can submit it at the start of class on Wednesday, 11/12/2014.

Introduction

In the energy conversion project, you will be launching a t-ball that weighs about 0.125 kg as far as you can using 50 Joules (or less) of stored energy. Some of you may decide to use elastic energy to store the 50 Joules you have available, and you will all have to provide measurements and calculations to the instructors that show your apparatus meets the required specifications. Therefore, it is important that you understand how to measure and calculate the energy stored in an elastic structure, such as a spring. In this ESBA, you will measure the spring constant of a spring and use your results to calculate the elastic energy that is stored due to the deflection.

Required Equipment

- A-frame with empty buckets and springs attached (located in your classroom)
- Weights (located in your classroom)
- Tape measure

Activity 1: Spring Data Collection

1. When your team's turn arrives, select the available spring on the A-frame.
2. From a stationary reference point (this point does not move) on the A-frame, measure the vertical distance of the last coil at end of the spring that will be in contact with the bucket handle later. Record this value, in Row 0 of the *Spring Length* column of Table 1. This represents the un-deflected (with no weights attached) length of the spring.
3. Hang the bucket from the spring using the hook provided making sure that the bucket is upright and balanced at the end of the spring, and wait for all movement in the spring to stop.
4. Record the weight of the empty bucket in the *Total Weight* column of row 1 in Table 1. The mass of each bucket is 0.908kg. To convert this mass to a weight (which is a force), we use weight = mg. The weight of each bucket, then, is 8.898 N (= 0.908 kg * 9.8 m/s^2).
5. From the same stationary reference point as in Step 2, measure the vertical distance (in meters) of the last coil (the same coil used in Step 2) at end of the spring that is in contact with the bucket handle. Record this value in the *Spring Length* column in Row 1 of Table 2. Calculate and record in Table 1 the *Total Spring Displacement* as the mathematical difference between the values recorded in the *Spring Length* column in Rows 0 and 1. Use the following conversion values if necessary: 1 in. = 2.54 cm, 100 cm = 1m
6. Add a weight to the bucket. In the next available row of Table 1, record the *Total Weight* value to reflect the new weight of the bucket and all the weights inside. The weights you will be adding are in units of lb_f, and 1 lb_f = 4.448 N. You'll need to do the unit conversions.
7. Wait for all movement in the spring/bucket to stop. From the same stationary reference point as in Step 2, measure the vertical distance of the last coil (same location used in Steps 2 & 5) at end of the spring that is in contact with the bucket handle. Record this vertical distance in the *Spring Length* column, and update the *Total Spring Displacement* column as the mathematical difference between the *Spring Length* you just recorded and the *Spring Length* given in Row 0 of Table 1.
8. Repeat Steps 6 – 7 three more times (completing subsequent rows of the table) until you have all of Table 1 completed.
9. Put all the weights back in the original storage location, unhook the bucket from the spring, and clean up your work area.

Table 1: Spring data

#	Total Weight (N)	Spring Length (m)	Total Spring Displacement (m)
0	0		
1			
2			
3			
4			
5			

Activity 2: Calculating the K constant

Transfer the data from Table 1 into Excel, and create a graph of Total Weight (N) vs. Total Spring Displacement (m). Choose "scatter" or "x-y" as your chart option, and **make Total Weight the vertical axis**. When you have the plot completed:

1. Click on the chart
2. If you have a "Layout" option in your ribbon menu, go there and choose "Add Trendline" and then "Linear Trendline"
3. If you do not have a Layout In the Design menu, click on "Add Chart Element", go to the Trendline option, and select Add Linear Trend Line.
4. Right click on the line itself, and select "Format Trendline".
5. Select "Display Equation on chart". The slope of this line is your estimate of the k value. (The slope of the line is the "m" in a "y = mx + b" type line equation)
6. Write the value of k below:

k = ________________N/M

Activity 3: Energy Calculations

Record the final spring displacement value you observed in Activity 1. (Remember, this value should be the Total Spring Displacement value in the final row of Table 1.)

_________________ meters

The energy stored in a spring is given by $E_e = k\,\frac{1}{2}(x^2)$, where k is the spring constant (calculated in Activity 2), and x represents the spring displacement value. If you stretched the spring to the displacement value recorded above (your final Total Spring Displacement value from Table 1), how much energy would the spring store?

E = __________Joules

Then, assuming each spring had the same k constant and was getting displaced the same amount, how many springs would be needed to store 50 Joules of energy?

Activity 4: Reflections

What did you learn about elastic energy storage in springs today?

How do you anticipate that you'll use what you learned today in the context of the energy conversion project?