Physics 120 Lab 5: Breaking a Karate Board

Introduction

A standard element of martial arts demonstrations is the breaking of a solid wooden board with a single punch. In this lab we will determine how fast your hand would have to be moving to provide enough energy to break a typical karate board. The basic idea is to apply an increasing static load to a board until it breaks, and then determine how much potential energy was stored in the board just before it broke. You can then apply conservation of mechanical energy to determine the minimum speed that your hand would have to be moving to break the board.

Note that some of the questions in this lab require energy methods, and so will be completed later this week in class.

Apparatus

The experimental apparatus that we will use in this lab consists of a cradle that hangs from a karate board supported by a wooden A-frame. The weight of the cradle is increased by loading it with bricks, one at a time. For each addition of a brick, the displacement of the center of the board from the equilibrium position will be measured using a depth gauge. This gauge measures small changes in increments of 0.001 inches.

Procedure

Part 1

1. Determine the mass of the cradle and its uncertainty. To do this measure and record the mass of the cradle at least seven times and perform a statistical analysis with Excel to determine the mean and standard deviations of the measurements. Change the position of the cradle on the scale slightly for each mass measurement.

2. Place the karate board horizontally on the two metal rods of the A-frame.

3. Set the depth gauge so that the anvil of the depth gauge is touching the center of the board. Mark the location of the anvil on the board with a pen or pencil and zero the dial on the depth gauge.

4. Hang the cradle from the board so that the horizontal metal bar supporting the cradle is right next to the spindle of the depth gauge. Record the displacement measured by the depth gauge. Estimate the uncertainty in the displacement measurement.

5. Add one brick at a time to the cradle and record the displacement after the addition of each brick. Continue until the board breaks. **Please keep your toes and fingers from under the cradle at all times.**

Part 2

1. Determine the mass of an average brick and its uncertainty. To do this measure and record the mass of at least seven individual bricks, enter these measurements into an Excel spreadsheet, and determine the mean and standard deviation for the mass of a brick.

2. Create an Excel spreadsheet to contain your force and displacement values.

3. Estimate the mass of your fist and its uncertainty. (You should explain how you did this in your lab report.)

4. Assuming that you can model the board as a spring, use conservation of mechanical energy to derive an equation for the minimum speed with which your fist must strike the board in order to break it. (Hint: Consider the initial situation to be just before your fist hits the board and the final situation to be just before the board breaks.)

Analysis

1. Use Excel to create a graph of force applied to the board F (y-axis) versus displacement x (x-axis). Does the board appear to obey Hooke's law? Can it be modeled as a spring?

2. Fit the data to determine the effective spring constant for the board. Determine the uncertainty in the spring constant using a linear regression analysis (consult your instructor).

3. Calculate the minimum speed at which your fist must move to break the board. Also, determine the uncertainty in this value.

Writeup

Hand in the following:

1. Graph of your data, with figure caption and properly labelled axes.

2. Table of your data, with table caption and labelled columns (with uncertainties).

3. Neatly written calculation of the minimum speed of your fist, including the uncertainty analysis.

4. Discussion and Conclusions paragraph