Physics 110

Breaking a Karate Board

Name ______________ Section ______________ Date ______________

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.

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 0.01 mm.

Procedure

1. Determine the mass of an average brick. To do this measure the mass of seven individual bricks and record the values in the table below. Calculate the average of the seven measurements and record the value in the table.

Measurement	m_{brick}(kg)
1	
2	
3	
4	
5	
6	
7	
Average	

2. Prepare an Excel spreadsheet with the column headings: brick #, m (kg), x (m), and F (N).

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

4. Set the depth gauge so that the anvil (see handout Using a Dial Indicator) 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.

5. 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 brick # (0 in this case) and the displacement measured by the depth gauge in the Excel spreadsheet. (See handout Using a Dial Indicator on how to read the depth gauge.)

6. Add one brick at a time to the cradle and record the brick # and 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.**

Analysis

1. Do the calculations to fill in the other columns of the spreadsheet. Print the final spreadsheet and attach it to the lab when you hand it in.

2. Record the maximum displacement of the board just before it broke x_{max} in the space below. Also, estimate the uncertainty.

3. Use Excel to create a graph of force applied to the board $F\,(N)$ (y-axis) versus displacement $x\,(m)$ (x-axis). Does the board appear to obey Hooke's law? Can it be modeled as a spring? (Answer these questions in the space below.)

4. Fit the data to determine the effective spring constant of the board. Determine the uncertainty in the spring constant using a linear regression analysis (consult your instructor). Record the result with uncertainty and units in the space below. Also, print the graph showing the fit and attach it to the lab when you hand it in. Make sure that the graph is properly labeled.

5. Estimate and record the mass of your fist m_f and its uncertainty in the space below. Also, explain how you estimated the mass of your fist.

6. 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. That is, derive an expression for v_{min}, in terms of the maximum displacement of the board before it broke x_{max}, the effective spring constant of the board k, and the mass of your fist m_f. Show your work in the space below. (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.)

7. Using your values for the maximum displacement of the board before it broke x_{max}, the effective spring constant of the board k, and the mass of your fist m_f, calculate the minimum speed at which your fist must move to break the board. Also, determine the uncertainty in this value from the uncertainties in x_{max}, k, and m_f. Show your work in the space below.