1988

Energy in Perspective Laboratory #9: A Variety of Physical Systems, or Determining Relationships for Four (Yes, 4) Experiments

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A Variety of Physical Systems

or: Determining Relationships for Four (yes, 4) Experiments

Introduction

Your task will be to collect data from a variety of physical systems and find the relationships between the manipulated (independent) and responding (dependent) variables using a graphical method. **You now know two different ways of analyzing data using two different graphs, either Cartesian or log-log.** It will be up to you to decide which to use.

Remember: contrastive features, range of variation, and distribution in larger contexts are all necessary to be able to understand something. In physics language that means **explore as wide a range of the manipulated variables as seems reasonable.** In fact, every physical system is linear if you take a narrow range of values. Thus, to insure that your analysis is appropriate, be sure you double or triple, etc. the values you select for your manipulated variables.

Physical Systems to Examine

For each system make a list of its variables. Clearly state what you will manipulate. Keep ALL other properties constant and measure the values of the responding variable. **Then analyze your data using a graphical method. Find the mathematical relationships between variables. They should be in the form of either:**

$$y = m*x + b \text{ or } y = A*x^m.$$

The systems we will be using are:

1) Motion of Objects on a Level Surface Being Pulled by a Weight

2) Squeezing Air

3) Oscillating Coffee Can

4) Vibrating String

You will be allowed about 40 minutes with each system. If you finish data collection sooner than that, either begin your write-up activities or study the written material for the next system you will examine.

Hint: The write up will require the following:

I PURPOSE

II EXPERIMENTS

A) Concisely describe the purpose and procedure of each experiment.

B) Include data analysis of each experiment

1) Any graphs made

2) Equations for relationships between variables.

C) Discuss similarities and differences among the experiments.

III CONCLUSIONS AND DATA

State any conclusions from the lab. Include data sheets.

1. Motion of Objects on a Level Surface Being Pulled by a Weight

Purposes: Analyze the motion of three different objects across a level table when pulled by a weight: 1) a hot wheels car, 2) an internal fly wheel car, or 3) a box.

Procedures: Adjust the motion of the system, shown below, by adding masses to the object on the table or by changing the pulling weight, so that the object travels about 10 cm from rest in one second, or more. Then, use the **distance of motion as the manipulated** (independent) variable and the time taken to travel that distance as the responding (dependent) variable. Measure the time for **5 different distances**, e.g. for 10 cm, 20 cm, 30 cm, etc. Be sure to record the total mass of the moving object.

Repeat this complete procedure with a different mass added to the object (e.g. double the total mass of the moving object). Once again adjust the pulling weight so that it takes at least one second to travel about 10 cm from rest.

Now do this complete experimental procedure for another object, until you have collected data for all 3 of the objects listed above.

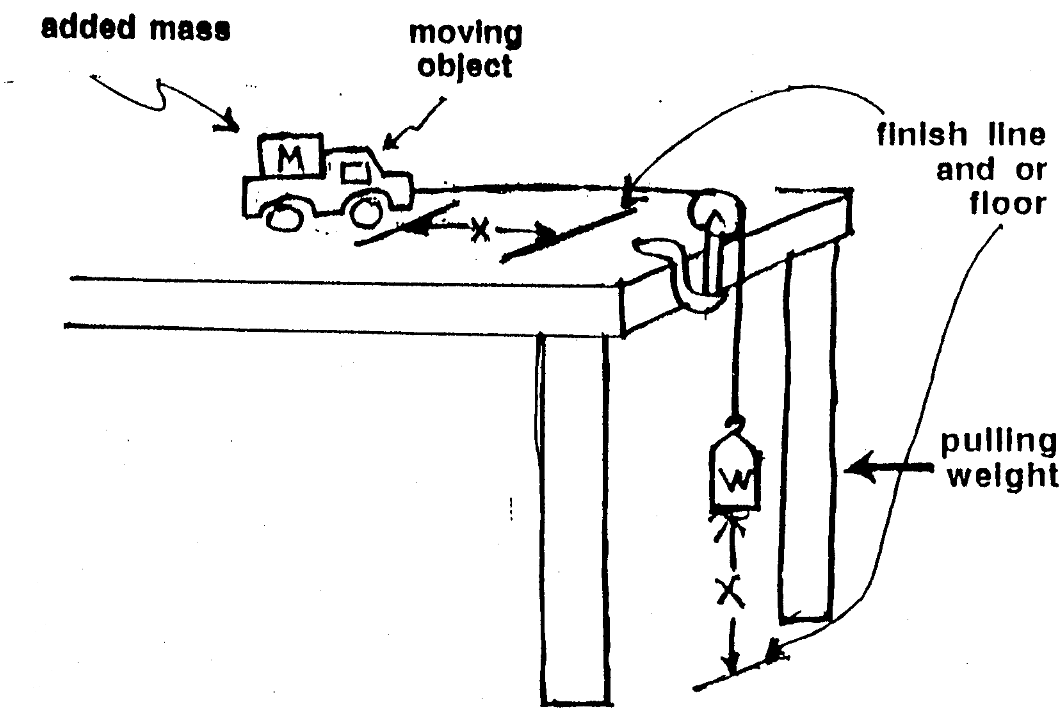


Figure 9-1

You may draw all sets of data for different masses of each moving object on one graph. Use a different symbol on your graph for the data points for the different masses and different objects. Clearly label the axes and which object you used.

Use a graph that makes a line. That is, if the data is plotted on a Cartesian graph and is not a line, use log-log paper. **Write the equation for the time as it depends upon the distance.** That is, $y = m*x + b$ or $y = A*x^m$ where y = time and x = distance.

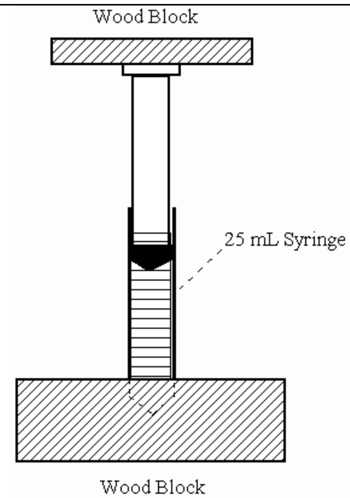
2. Squeezing Air

You have often squeezed some air down into a small volume to fit into a bicycle tire, basketball or balloon. In this experiment we will do an idealized squeezing air experiment.

Examine the squeezing air apparatus.
- What are its properties?
- What variable can you manipulate (independent) ?
- What variable will respond (dependent) to your manipulations?

Perform a squeezing air experiment. Take **6 measurements** so that the air is squeezed from more than 25 cm^3 to less than 10 cm^3. Determine the starting mass value by measuring the mass of the plunger and the wooden block.

Try your raw data on both Cartesian and log-log paper. **Find an equation that relates the two variables.** (Include both of your graphs in the write-up)

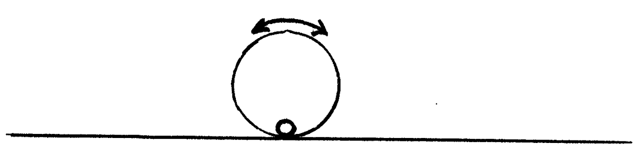


Now, an invisible force, namely the weight of the air above the physics lab, is pushing down on the plunger. It is estimated to be about 4.6 kg. If you add 4.6 kg to your values and re-draw your graphs. does that make your Cartesian or log-log plot more linear? If it does then find a new equation.

3. Oscillating Coffee Can

When **slightly displaced**, a weighted coffee can oscillates back and forth.

Lab Experiment: If a weighed coffee can is slightly displaced from rest on a level table it will oscillate back and forth.



The period of oscillation changes if you change the size of the object attached to the side of the can.

Given: coffee can with copper rings inside, various sizes of wooden rods, clock, meter stick, pan balance.

Figure for instructor, Figure 9-3

- List the variables that may change its period of oscillation.

Select the mass of the rod as a manipulated (independent) variable - you may want to use first wooden and then metal rods to get a wide range of variation in the mass. Use at least **6 different masses.**

- What influence does the amplitude of the oscillation have on the period?
- How would you go about testing your hypothesis?

Find the mathematical relationship between mass of rod and period of oscillation.
- Discuss the influence of the amplitude of the oscillation on the period.

4. Vibrating String

Purpose: A string can vibrate steadily only in patterns such as those shown below. In this experiment a string is tied to a vibrator at one end and suspended over a pulley and attached to a mass at the other end. You can study the effects of changing the tension in a string while it is vibrated.

Procedure: You are to add masses to the string in order to reproduce standing wave patterns as shown in the diagram below. Record the number of nodes n (the number of places where the string is not vibrating). This will be your manipulated (independent) variable. The corresponding mass will be the responding (dependent) variable.

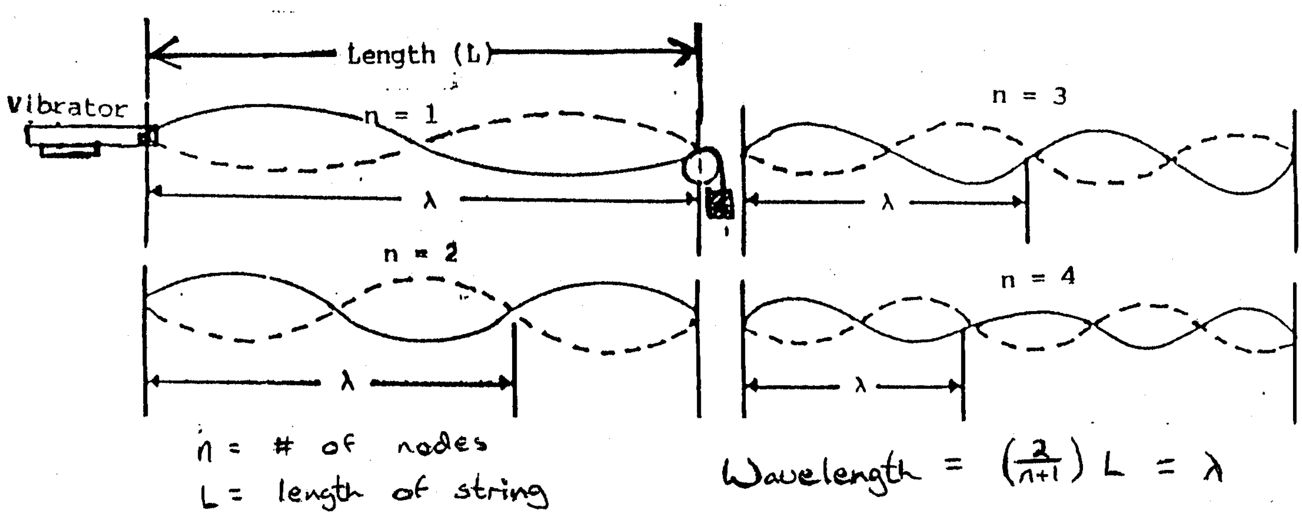


Figure 9-4

Find the mathematical relationship between the wavelength of the vibrations and the mass applied to the string. Use whichever graph paper is appropriate. Up to **8 nodes** are possible for data collection.

• What other factors do you think affect the vibration of a string (Think of a guitar.)?

Write-up:

Note: you may need to get some log-log paper from the bookstore for this assignment.

<u>Include the answers to all questions asked in the lab pages !!!</u>

A. For each of the four activities write the following:

I PURPOSE
II EXPERIMENTS
   A) Concisely describe the purpose and procedure of each experiment.
   B) Include data analysis of each experiment
      1) Any graphs made
      2) Equations for relationships between variables.
   C) Discuss similarities and differences among the experiments.
III CONCLUSIONS AND DATA
   State any conclusions from the lab. Include data sheets.

B. Additional analysis activities:

1. Two ADAPT students collected the following data for the swinging string experiment:

length of string(centimeters)	time for 10 periods(seconds)
30	11.0
60	15.5
90	19.0
150	24.6
300	34.8

Determine the relationship between the period of oscillation and the length of the string.
• The longest string that can be hung in the stairwell of the physics building is about 8.2 metres in length, what would be the period of such a swinging string ? Explain.
• Can you hang a string from the top of the physics building and get a period of oscillation of ten seconds? Explain your reasoning.

2. Two more ADAPT students collected the following data for the oscillating Slinky™ experiment:

mass on the Slinky™(grams)	time for 10 periods(seconds)
20	4.0
50	6.3
100	9.0
200	12.6
500	20.1

Determine the relationship between the period of oscillation and the mass on the Slinky™.
• The largest mass that could be hung on the Slinky™ in a classroom in Ferguson Hall is about 1.0 kilograms , what would be the period of such a swinging string ? Explain.
• If you want the period of oscillation to be 4.0 seconds, what mass would you need to hang on the Slinky™? Explain your work.