Lab: Finklebottom & Priest   AP Physics

Background

Objectives

Equipment

Procedure

1. Read the brief research article (Finklebottom & Priest, 2004).

2. Design an experiment to *support* or *refute* their conclusions.
        Talk to instructors to find out what equipment might be available to you.

3. Collect data

4. Process data
        There are many ways to do this—talk to instructors if you need assistance.

5. Come to some conclusion concerning the validity of Finklebottom & Priest's claim.
   a.   If your data supports F & P's claim, provide specific quantitative evidence of this.
   b.   If your data does *not* support F & P's claim, use your data to develop your own mathematical model
        of how air friction affects the motion of a falling body.[1]

6. Produce a 4-5 page summary of your findings, including all pertinent information.
        This will almost certainly include a procedure, a graph, a discussion of your results, and conclusions.

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[1] A critical question is, is air drag R proportional to v or to v^2? Section 6.4 in the textbook has some information that discusses these two relationships, and look at the Additional Notes (next page).

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Additional Notes

1. As suggested in Procedure Step #5 and the footnote, air friction typically affects a falling body in one of two ways:
   a. air friction R is proportional to v ($R \propto v$), or
   b. air friction R is proportional to v^2 ($R \propto v^2$)
2. The two models that correspond to these two situations are:
   a. $R = -bv$, where b is a constant, or
   b. $R = \frac{1}{2}D\rho Av^2$, where D, ρ, and A are constants that represent the experimentally-determined *drag coefficient*, fluid density, and cross-sectional area of the falling object, respectively.

3. Perhaps a convenient way of determining which of these is more applicable to the F & P situation would be to graph R vs. v and R vs. v^2 and see which one is closest to linear. This is a nice approach to use if you can collect the data, with air friction R varying with velocity v. but it turns out to be a little tricky to collect that R data.
4. We have an alternative. If we can measure the terminal velocity of a falling object, we'll know v, and we can calculate R based on the mass of that object:

   $F_{net} = ma = 0$

   $R - mg = 0$

   $R = mg$ (at a terminal velocity v)

   If we can increase the mass of the object (without changing its shape), we'll get a new terminal velocity v, and a new air friction R. Collect a number of data points, and then we can plot R vs. v and R vs. v^2 as suggested above and see what the best-fit line for those relationships looks like.

Data Analysis with Logger Pro   AP Physics

How to "Fit a Curve" to your Data
After collecting data, it's often useful to examine it by determining whether or not it fits a predicted model.

> **Example:** Is Free Fall acceleration constant?
> If we collected position, time, velocity, and acceleration data for a freely-falling object, we could look at various graphs of that data. We'd expect to find that:
> - the acceleration vs. time graph was a flat line indicating an acceleration of -9.8 m/s^2,
> - the velocity vs. time graph was a straight line with a constant slope of -9.8 m/s^2, and
> - the position vs. time graph was a quadratic function of the form $y = ax^2 + bx + c$,
>
>   where **a**=-4.90. (Right? $y = ax^2 + bx + c$ has the same form as $\Delta x = v_i t + \frac{1}{2}at^2$--the variables just have different names, and some of them have been switched around a little.)

Logger Pro has the ability to overlay "model graphs" on top of your "data graph." By playing around with the graphs of different mathematical models, you can determine how well your data matches any given mathematical model.

Here's how you get Logger Pro to do that:

A. Collect data, and graph it.

B. Select the graph you want to put your model on. If you only want to examine part of the graph, you can click-and-drag the cursor over the section you want to focus on, and then select **Analyze-->Zoom Graph In**.

C. Select from the menu bar **Analyze --> Curve Fit**. In the Options section on the right, click the **Manual** button for Curve fitting.
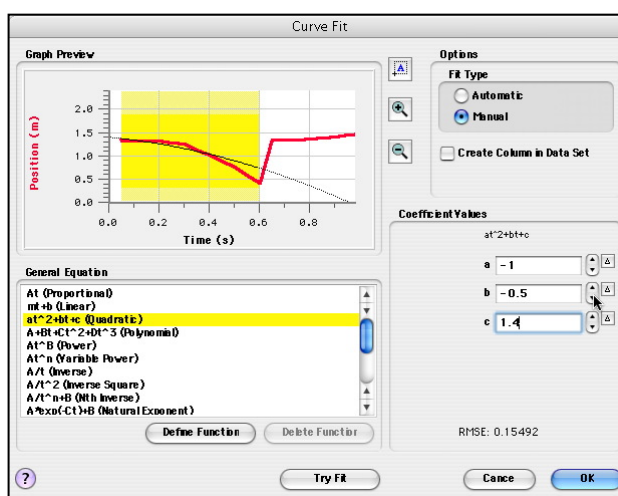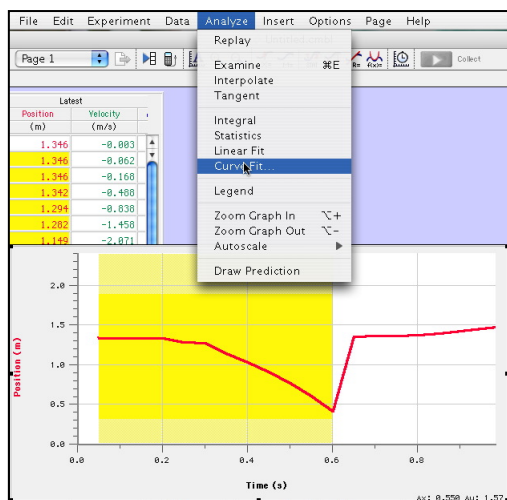
D. You'll need to predict whether or not you think the data shows a *linear* relationship, a *quadratic* relationship, an *inverse square* relationship, a *power* relationship, etc. In the **General Equation** section, select the type of equation you'd like to model. As soon as you do this, that model will appear in the small window above, superimposed over your data graph.

E. It is highly unlikely that the model that has been placed will fit your data perfectly, at least not at first. In order to get your model to match the data as closely as possible, you'll now need to move over to the **Coefficient Values** section, and begin playing with the numbers in there--you can either enter the coefficient values directly (negative values too!), or use the Up- and Down-arrow keys to the right to scroll through values. Keep an eye on the **Graph Preview** window to see how close your model is matching your data.

F. Notice the RMSE value listed beneath the Coefficient Values. This "Root Mean Square Error" is a calculated measure of how far away, on average, your mathematical model is from matching your data. The smaller this value, is, the closer your mathematical model is to fitting the data you actually collected.

G. Once you think you've got a good fit, click **Ok** to exit the Curve Fit dialog box and return to your graph. Note that once you've clicked "Ok," you won't be able to edit your Curve Fit--you can always go back, though, and make a new Curve Fit, then delete the first one.