Computer Plotting and Fitting

Object: To demonstrate proficiency in using a computer to manipulate, plot, and fit data.

Introduction: In order to analyze and interpret the data you will collect during your experiments, you will often need to use a computer program to help visualize and fit your results. Plotting the data in a suitable format can make it much easier to understand relationships between the different variables and to spot trends. In this laboratory you will calculate the value of γ (relativistic scaling factor) as a function of speed and prepare three different presentations of these data by plotting the same data set with three different types of scaling for the axes. Remember:

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

Apparatus: This lab will require a computer and software suitable for analyzing and plotting data. You are welcome to use your own computer for this laboratory, or there are open computers available for use. Software programs such as Excel, Origin, Mathematica, or Sigma Plot can be used for preparing the figures, although you can use any software you like.

Method: The central objective of this laboratory is to investigate the behavior of $\gamma(\beta)$ over a wide range of speeds. Acquiring the data for this is straightforward.

1) Compute $\gamma(\beta)$ for values of v ranging from 0 to 0.999. Find γ for at least 10 values of β between 0 and 0.9, at least 10 values between 0.9 and 0.99, and at least 10 values between 0.99 and 0.999. You can do this by hand, but it is much easier to input all the β values into a column in Excel (or Origin or Sigma Plot), and then perform the transformation in the equation above on the entire column at once.

Analysis: To investigate these data you will prepare three different figures and answer a number of questions.

1) Plot γ versus β over the entire range of β. What value of $v=\beta c$ is required to have $\gamma=1.1$? $\gamma=2$? Explain why non-relativistic classical mechanics gives reasonable answers for most of the problems people investigated from ~AD 1600 to ~AD 1900.

2) When plotting data with a large variation (like the value of γ as a function of β) it is often useful to use a logarithmic scale to more clearly see both small and large changes. Plot $\log(\gamma)$ versus β over the entire range of β. How does this change the curve from plot 1 above? It is easier to resolve differences in the γ values at smaller values of β? How could the data be

presented to even more clearly show how γ changes at small β? (Hint: consider subtracting off some constant background term from γ).

3) It is often useful to plot functions of x and y rather than x and y directly to spot functional relationships. Plot $1/\gamma^2$ versus β. What kind of curve do you get? Fit this curve to find the functional form of $\gamma(\beta)$.