171.308/608: Advanced Physics Lab
Warm Up Exercises

Due Feb 11, 2013. Show all work for credit.

1. **Latex.** Compile the lab report example in the tutorial "Basic LaTex" from the course wiki. Why is it smart to use the the "label" and "ref" commands to refer to tables and figures from the text? Bonus point: what is the difference in LaTeX formatting between left quotation marks (``) and right quotation marks ('')?

2. **Significant Figures.** Suppose an instrument that measures weight returns a value of 1.2342842 N and you calculate the error on the measurement to be (without regard to significant figures) 0.234051 N . How would you report this measurement in your lab report? Would it be appropriate to report a measurement of 1.2342842 ± 0.234051 N? (Hint there is not a unique numerical answer to this: use your common sense.)

3. **Error on the Mean.** Supposed you measured the length of a wiggly worm a number of times and found the following values: 11.12, 11.41, 9.99, 11.01, 7.69, 10.11, 10.66, 10.17, 7.89, 11.95 cm. Estimate the mean and the variance of the length measurements. Estimate the standard deviation on the mean.

4. **Weighted Mean.** Suppose you made the following measurements of another worm (again in cm): 6.74, 4.87, 6.17, 8.09, 3.05, 2.80, 4.93, 4.70 cm. This time though, the variances for all measurements are known and are not the same: 2.4, 2., 3., 1.8, 2.5, 2.8, 1.9, 2.5 cm^2. What is the weighted mean and the error on the weighted mean?

5. **Simple Error Propagation.** Suppose you have a function $f(x) = ax^2 + bx + c$ of a measured value x. And suppose your measurements of x are given by the measurements (including variance) of the previous problem on the weighted mean. Estimate the corresponding variance of f.

6. **Modeling data.** You take measurements of a trajectory at times $t = 0., 0.5, 1., 1.5, 2., 2.5, 3., 3.5$ seconds. You measure trajectory positions $x = 4.16, 7.22, 9.92, 18.11, 26.70, 35.89, 49.08, 61.50$ cm. Associated with these measurements are variances $\sigma_x^2 = 2.4, 2., 3., 1.8, 2.5, 2.8, 1.9, 2.5$ cm^2.

   (a) **Fitting the data.** Model the data $x(t)$ assuming the trajectory x should be a quadratic function of t: $x(t) = ax^2 + bx + c$. Give the best fit values and associated errors for the parameters a, b, and c.

   (b) **Plotting.** Plot the x data with error bars versus t. Plot the best fit model curve through the data.

   (c) χ^2 **and PTE.** What are the number of degrees of freedom associated with your data+model? What is the χ^2 of the fit? What is the probability to exceed (PTE) this χ^2? If you repeated this experiment ten more times, approximate how many of these extra experiments would have a χ^2 greater than the χ^2 associated with this measurement.

7. **Linear vs Non-linear.** What is the key difference between a linear fit/model and a non-linear fit/model? (Hint: linear and non-linear refer to how the model depends on the parameters.) Did the previous problem involve a linear or nonlinear model?