Winter, 2010

Physics 780.20: Assignment #2

This assignment is a follow-up to Sessions 3 and 4. It is intended to give you additional practice in the basic tasks from class (like coding algorithms), that we'll need repeatedly and build upon, and to verify to me that you can do them. Please ask questions! It is due at the end of the day (midnight) on Friday, January 29.

To "hand in" the assignment, email me (at `furnstahl.1@osu.edu`) a zip archive (see below) with your makefiles and programs (with the answers to any questions in the comments at the top) and a postscript file of the log-log plot. Use C++ and gnuplot. Comment your codes with your name, etc., as in the sample codes from class. *Check the 780.20 webpage for suggestions and hints.* Please ask questions and give feedback early and often.

The problems here are really all parts of the same computational problem of calculating integrals. You can combine them in any way that is convenient (i.e., you don't need separate main programs for each sub-section). Note that the session notes have lots of help info and that a sample code for GSL integration is included in the session 4 zip archive.

1. **Follow-up/Completion of Session 3**

   (a) Write routines to do integration of any user-supplied function over a given (finite) interval in double precision using Simpson's rule, the Milne integration rule (see the Session 4 notes), and an appropriate integration routine from the GSL. (If you want, you can base your Simpson's rule routine on the one from class, but note that the interval is not general in that one — it assumes that zero is the lower limit. You might want to check the hints for other suggestions.) Test your routines with a non-trivial test integral (*choose an integrand we haven't used yet and not as simple as a polynomial*). The test program and routines should be in separate files and you should create a makefile to compile them.

   (b) Extend your program to generate an appropriate data file and plot (with a gnuplot plot file that makes a postscript file) to do an error analysis of the integration methods from the first part.

   (c) Find *graphically* (i.e., by analyzing the plot from the last section) the optimum number of points to use for the Milne integration rule in double precision and explain how this makes sense analytically.

   (d) (BONUS) Evaluate one of the singular integrals from the handout (1094 Session

4) directly using Simpson's or Milne and a GSL routine, and then compare to the answer found by applying a method discussed in the handout or session notes (or in Numerical Recipes).

2. **Empirical error analysis.** How would you analyze your integration results if you didn't know the exact answer? Use the method from the section on "Empirical Error Analysis" from the Session 4 background notes to analyze one of the integration rules (your choice of rule and integral!) to find the approximation error.