Winter, 2006

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, which 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 27.

To "hand in" the assignment, email me (at `furnstahl.1@osu.edu`) a "tarball" (see below) of your program and makefile (with the answers to any questions in the comments), a postscript file of the log-log plot, and a Mathematica notebook with the command(s) and result. (Send the tarball as an attachment.) Use C++ and any plotting program you want (gnuplot recommended for now). *Check the 780.20 webpage for suggestions and hints if you get stuck.* Please give feedback early and often.

To make a tarball, create a directory with the name: your_name_ps1 (replace "your_name" by your last name!), e.g., `mkdir furnstahl_ps2`
Copy all of the files to pack up into that directory. Then give the command:

```
tar cfvz furnstahl_ps1.tarz furnstahl_ps2
```

and you're done! The command "tar tfvz furnstahl_ps1.tarz" lists the contents, so you can check that you've packed all the files correctly. [Note: The "c" is for "create a new archive", the "f" is for file and goes with the archive name furnstahl_ps2.tarz, "v" is for verbose mode (say what is going on), and "z" means to compress the tar file with gzip (tar stands for "tape archive").]

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 codes for each part). Note that the session notes have lots of help info and that a sample codes for GSL integration is included in the session 4 tarball.

1. Write routines to do integration of any given function over a given (finite) interval in double precision using Simpson's rule, the Milne integration rule (see Table 4.1 on page 48 of the Landau/Paez handout on integration), 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.) Test your routines with a suitable test integral (your choice). The test program and routines should be in separate files and you should use a makefile to compile them.

2. Write a main program that calls your routines to do part 4. of Section 4.8, "Assessment: Empirical Error Estimate" in the Landau/Paez handout for an integrand of your choice (but not the one in the book!) with the Milne integration rule. The table they want can just be an output file from your code.

3. Find graphically the optimum number of points to use for the Milne integration rule in double precision and show that this makes sense analytically.

4. Evaluate one of the singular integrals from the handout (1094 Session 3) 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).

5. (BONUS) 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.