Winter, 2009

Physics 780.20: Assignment #1

This assignment is designed to give you 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 Tuesday, January 20.

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 postscript files of the required plots. 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 if you get stuck.

To make the zip file, create a directory with the name: your_name_ps1 (replace "your_name" by your last name!), e.g., `mkdir furnstahl_ps1`
Copy all of the files to pack up into that directory. Then give the command:

```
zip -r furnstahl_ps1.zip furnstahl_ps1
```

and you're done! The command "unzip -l furnstahl_ps1.zip" lists the contents, so you can check that you've packed all the files correctly.

1. **Summing up vs. summing down.**

   This problem is taken from problem 3 in section 3.4 of the Landau–Paez *Computational Physics* text, which examines the summation of $1/n$. The analysis should be similar to the one on finding the roots of quadratic equations from class (you might find the quadratic_equation_2.cpp printout useful). Consider the two series for integer N:

   $$S^{(\mathrm{up})} = \sum_{n=1}^{N} \frac{1}{n} \qquad S^{(\mathrm{down})} = \sum_{n=N}^{1} \frac{1}{n}$$

   Mathematically they are finite and equivalent, because it doesn't matter in what order you do the sum. However, when you sum numerically, $S^{(\mathrm{up})} \neq S^{(\mathrm{down})}$ because of round-off error.

   (a) Write a program (with makefile) to calculate $S^{(\mathrm{up})}$ and $S^{(\mathrm{down})}$ in single precision as functions of N. Make sure you include appropriate comments and indent it consistently.

   (b) Make a log–log plot of the difference divided by the sum versus N and turn in a postscript file of the plot.

(c) Discuss the interpretation of the linear region on your graph and explain briefly why the downward sum is more precise.

2. **Spherical Bessel Functions.**

   The goal here is to complete (some of) the Bessel function activities from Session 2. In particular,

   (a) Turn in a code that generates the output file needed for Bessel 2, part 3.

   (b) Turn in a postscript plot of the error vs. x made from that output file *with an interpretation of the different regions of the graph.* (Put your analysis in the comments of the code.)

   (c) Add the GSL routine (from Bessel 3) to your code (so only one code is needed in the end), with a new column in the output file being $j_{10}(x)$ from GSL.

3. (BONUS) **Randomness of round-off errors.** The "Are Round-Off Errors Random" task from the *780.20: 1094 Session 2* handout. This is not a required program, but I recommend giving it a try if you found the other parts easy.