Spring, 2008

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 Monday, April 7.

We're going to try out Carmen as a means to collect the assignments. To "hand in" the assignment, upload to Carmen a zip archive of your programs (with the answers to any questions in the comments at the top) and postscript files of the required plots to the 780.20 Assignment 1 drop box. Use C++ and any plotting program you want (gnuplot is recommended). 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. Please give feedback early and often.

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:

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

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

   (a) Write a program to calculate $S^{(\text{up})}$ and $S^{(\text{down})}$ 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.