

Physics 305, Fall 2009  
Homework 3  
Due Monday, September 14, 10 pm

This week we will use the same basic problem as last week – numerical integration — to practice writing and using functions, to explore the effects of using double precision and to see some of the problems you can encounter in “simple” integrations. You will also learn something about programming — using functions.

1. Modify the programs you wrote last week to do numerical integrations using the left-hand rule, the midpoint method, and trapezoid rule so that the function to be integrated is evaluated by code in a separate file from the driving routine. Use this opportunity to fix up any remaining problems in your codes from last week, and fix up your table and plot of errors versus bin size if necessary.
2. Now modify the programs to use double precision variables. Repeat your evaluation of

$$\int_0^{1.5} x e^{-x} dx$$

using double precision, using the number of bins 2, 4, 10, 20, 50, 100, 1000, 10000, 100000 and 1000000. Make a new table and log-log plot of the error versus number of bins, and compare your results to last week’s results.

3. Now let’s try an integral that you can’t do with your pencil! After all, that’s the point of this course. Use the midpoint or trapezoid rule to calculate

$$\int_a^b e^{-x^2} dx \quad .$$

Estimate your error. (You have to think about how to do this, since you don’t know the correct value. Using the integrate function on your graphing calculator is not legal. After all, that is just a computer program written by someone else that does the integral numerically.)

*(Assignment continues on next page)*

4. Now write a new function for this integral.

$$\int_0^2 \sqrt{x} dx$$

Compile it together with the same main procedures you used in the previous part. Use numbers of bins 10, 20, 40, 80 and 160 (doubling each time!). Use other numbers of bins if you think that will be useful. To cut down on the work, you can use just the left-hand rule and midpoint rule for this integral. Again, study the dependence of the error on the number of bins. This integral is not quite as nice as the one we have been practicing on, and you should expect to have to think a little bit to understand your results, or even to get good results. Make a log-log plot to explore the dependence of error on step size. What is the slope? (*Hint: it is not two*). In your report, compare your answers to the exact answer.

(*Extra credit:* Can you explain why this integral doesn't converge as well as the first problem?)