PY 421 - Introduction to Computational Physics

Homework # 3. February 14, 2013.

Due at discussion time (3PM) on Friday February 22.

The assignment:

For this assignment you must do five problems. The answers must be returned by computer as explained below.

Problem 1

Modify the code in image_blur_sub.f90 so that when the program image_blur is executed it opens a file, called “blur.data”, and writes on this file information on the number of blurring steps done by the program and the corresponding fluctuation of the image. Precisely, every time the program prints out the information on step number, average intensity and fluctuation, it should also write the step number and the natural logarithm of the fluctuation (1/2 times log(s2)) on the file “blur.data”. Please note that this file should only contain the values of step number and logarithm of the fluctuation, with no other characters, because it will have to be used in gnuplot. Also, each line should containing exactly two numbers: the step number and the corresponding logarithm of the fluctuation. Call the file with the modified code “image_blur_mod.f90”. It must be returned as explained below. The makefile “makefile.imblur” contains instructions to make the executable “image_blur_mod”. You should make it with the command:

make -f makefile.imblur image_blur_mod

Problem 2

Run the program image_blur_mod three times, with total number of steps 20,000, number of steps per print equal to 100, and blurring parameter equal to 1, 0.75 and 0.5 respectively (this make take several minutes). At the end of each run use the mv command to rename the file “blur.data” (for example as “blur.dt1”, “blur.dt2” ...) so that it does not get overwritten the next time you run the program. Plot the data from the “blur.data” files in a single graph which will have to be returned (see below). Notice that the graph will give the behavior of the fluctuation versus number of blurring steps on a semilogarithmic scale. You should observe that the rate of decay of the fluctuation asymptotically approaches a constant. Fit a straight line through the data corresponding to the blurring steps 18,000 and 20,000 and plot the three lines corresponding to the three values of the blurring parameter on the graph as well.

Problem 3

Calculate the expected theoretical asymptotic rate of decay of the fluctuation. You should base this calculation on the analysis of the algorithm presented in class (not just fit a line through your data). Return your calculation and the results you obtain for the size of your image and the three values of the blurring parameter in Problem 2. Compare your results with the slope of the lines you drew for Problem 2.

Problem 4

Write a simple program in F90, C or C++ which generates a file with the same name and format of the file "picture.pxa", with the same equal sizes, i.e. 256×256, for the picture. (Remember to save the file "picture.pxa" with your picture with another name before you run the program). Call this program make_pict.f90, make_pict.c or make_pict.cpp, according to the language you use. The program must ask for the values of the variables a_x, a_y and must create an image field given by

$$f(x,y) = \frac{765}{2}\Big(a_x[1-\cos(\frac{2\pi x}{x_w})] + a_y[1+\cos(\frac{2\pi y}{y_w})]\Big) \tag{1}$$

where x_w, y_w are the images width and height and x, y are integer value coordinates, ranging from 0 to $x_w - 1$ and $y_w - 1$ respectively. Return your code.

Problem 5

Run the code make_pict to generate a picture.pxa file with the same size as in the picture.pxa file used for problem 2 and with $a_x = a_y = 0.5$. Repeat the steps done for problem 2 and produce a new graph with the fluctuation data and expected asymptotic behavior for the new picture. You only need to return the graph with data and straight line fits.

Returning the assignment:

Doing the assignment and copying it onto the assignment file involves several steps that will use various utilities, such as plotting the data in the "blur.data" files, generating the file "assignment3.ps" or "assignment3.pdf" (see below), using the tar command to assemble the various files. I have prepared a file, posted in the notes subdirectory, called "asgn3_howto.pdf", which illustrates the basics of these steps for the students who may not be familiar with them. For help, please consult this file first. If you need further assistance, you are encouraged to ask me questions in class or privately.

For this assignment you must produce 3 files, namely:

-the file "image_blur_mod.f90" with the modified blurring code;

-the file "make_pict.f90", "make_pict.c" or "make_pict.cpp", with the code that produces an image with sinusoidal variation of intensity;

-a postscript file "assignment3.ps" or a pdf file "assignment3.pdf", with the calculations for problem 3 and the two graphs for problems 2 and 5.

These 3 files must be put together in a single file with the tar command (do not compress the resulting file) and the tar file should be copied on the CAS cluster to the file

~rebbi/courseware/asgn/asgn3.xxyyyy,

where xxyyyy stands for your personal identifier.

You can overwrite the file asgn3.xxyyyy as many time as you like until the deadline for the assignment. After the deadline, the write permission on the file will be revoked.

Grading:

20 points will be awarded for a correct solution to each one of the problems, for a maximum score of 100 points. Solutions which contain errors will be given partial credit, according to the severity of the error.