Physics 524 Week 14 Homework Exercise

Due: Tuesday 12/5/2023 at 10am

Due date reminder, etc.

Please email your completed assignment to the course TA by Tuesday, 10 am of next week. Assignments that are late by at most one week will receive at most 50% of full credit. We will not grade anything submitted more than one week late.

Your homework submissions—code, cell phone photos, etc. must include enough identifying information for us to tell who you are!

Problem

Modify vegasComputon_v2.py to produce a 10,000 event distribution of

$$f(x,y) = A_1 e^{-\frac{1}{2}\left(\frac{(x-\mu_{1x})^2}{\sigma_{1x}^2}+\frac{(y-\mu_{1y})^2}{\sigma_{1y}^2}\right)} + A_2 e^{-\frac{1}{2}\left(\frac{(x-\mu_{2x})^2}{\sigma_{2x}^2}+\frac{(y-\mu_{2y})^2}{\sigma_{2y}^2}\right)}$$

over the range 0 < *x,y* < 5. Produce the distribution using the same two methods we used in vegasComputon_v2.py:

(1) $\rho(x,y) = 1 \quad f(x,y) = A_1 e^{-\frac{1}{2}(\ldots)} + A_2 e^{-\frac{1}{2}(\ldots)}$ (i.e., brute force rejection method)

(2) $\rho(x,y) =$ final Vegas step-function grid after integration $\quad f(x,y) = \left[A_1 e^{-\frac{1}{2}(\ldots)} + A_2 e^{-\frac{1}{2}(\ldots)}\right]\left[\rho(x,y)\right]^{-1}$.

Compare the number of function evaluations required for these two methods.

The following parameters should be used:

$A_1 = 1.0$	$\mu_{1x} = 2.5$	$\sigma_{1x} = 1.0$	$\mu_{1y} = 2.5$	$\sigma_{1y} = 1.0$
$A_2 = 4.0$	$\mu_{2x} = 2.5$	$\sigma_{2x} = 0.1$	$\mu_{2y} = 2.5$	$\sigma_{2y} = 0.1$

Notes to minimize the number of modifications (it's somewhat ugly but will get the job done):

- Delete the method *dsig_dy(xnumber, yy)* and directly code the double Gaussian function in the method *dlum_dy1dy2(xnumber, x, y)*. The parameter *xnumber* has no meaning in this function, but leave it there.
- In *brute_force()* function, change the second line to
  ```
  dlum_dy1dy2_val_max = dlum_dy1dy2(xnumber,2.5,2.5)
  ```
  since the maximum of the double Gaussian is located at (2.5, 2.5).
- For the same reason, change the third line of the *vegas()* function to
  ```
  vegasRatioMax = vegasRatioFactor*dlum_dy1dy2(xnumber, 2.5,
  2.5)*NN*NN*delx[int(NN/2)]*dely[int(NN/2)]
  ```
  It's assumed that the maximum is located near the middle of the grid. That's the reason for int(NN/2).
- In *plot_results()*, modify the variables *titleRej*, *titleVrho* and *titleVegas* to generate appropriate plot titles. Also remove *xnumber* in the three print statements.

- To place the maximum of the function in the middle of the grid, we want to set *ym* to 5. The easiest way to achieve this is to set *xnumber* = -1.25 since *ym* is set to *xnumber/(xnumber + 1)* in the code. We also want the maximum plot range to be 5 in both the *x* and *y* directions, so set *xymax* to 5 when calling *plot_results()*. Also set *vegasRatioFactor* to 3.5. In other words, you can use the following command to generate the plots:

  ```
  plot_results(-1.25, 10000, 3.5, 5)
  ```
- You are welcome to tidy up the code if you want, but I suggest you try to implement the minimum changes to produce a working code first.