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Matlab2 Section C

A.] For part one, I began by plotting the cloverleaf shape given to us in the problem statement. I set the axis's to be X = [-600 600] um and Y = [-600 600] um. I adjusted the 4 circle's shapes and positions accordingly.

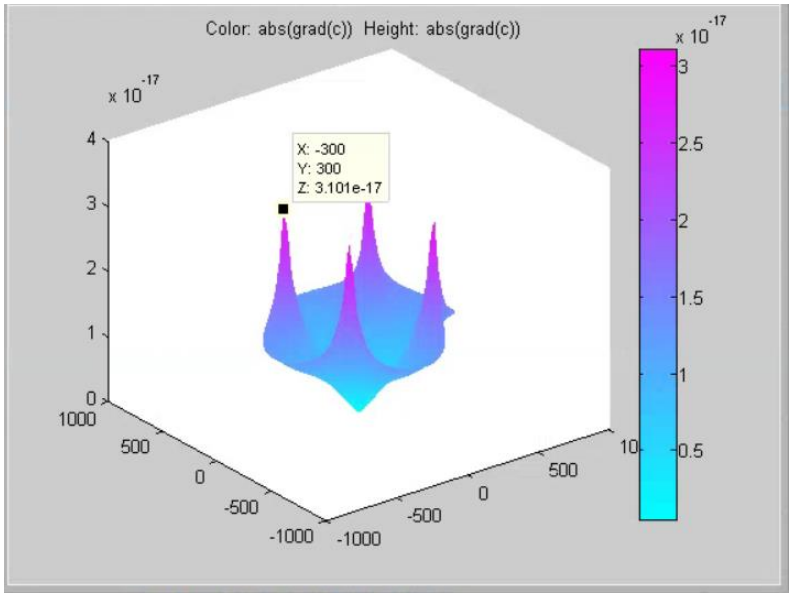
This scenario that was described is homogenous because the reaction is occurring spatially everywhere, in this case it is diffusing through all of the chambers. It was also stated that the cells stick mainly on the walls of each chamber. Due to these two facts, I knew I would need to be setting the boundary conditions equal to the concentration given (10 uM) since it is uniform. I chose to use the dirichlet setting for boundary conditions because the concentration is uniform and this part is a homogenous situation.

I did a few conversions as follows:

a. 10uM -> 10^{-14} umol/um^3
b. 400uM/s -> $4x10^{-13}$ umol/um^3 s
c. $6x10^{-2}$ cm^2/s -> $6x10^6$ um^2/s

I converted to these units to fit the graph (since the graph is in um, all of our units needed to be converted to um if they contained length).

1.) For the boundary conditions, using dirichlet, my values were (reasoning was explained in above paragraph): **H(weight) = 1** **r(concentration) = 10^{-14} umol/um^3**
2.) For the PDE parameters, I chose the ellipse function because we are dealing with perfect circles and also we are looking for a concentration gradient maximum. The parabolic function has a c' in it which is solely the absolute concentration value. The difference is that a maximum concentration gradient will be affected by the steepness in the concentrations that surround it. I also chose Q to be negative because the reaction is decaying.
D(diffusion coefficient) = $6x10^6$ um^2/s **Q(rxn rate) = $-4x10^{-13}$ um^2/s**
3.) The figure is the final plot of the solution. The maximum concentration gradient is **$3.101 x 10^{-17}$ umol/um^4** @ X = -300 um and Y = 300 um
I got these units by solving Fick's first law: Dc/dt = J/D = umol/um^4
As you can see from the figure, there are multiple points where the max occurs. (At (300, 300), (300, -300), (-300, -300) & (-300, 300)).
This is expected due to symmetry, but also because the system is homogenous and NO diffuses evenly though out all the chambers.



B.] For part B, I used the same cloverleaf sketch as part 1. This time, C & D are inert so I had to take that into account for boundary conditions. Unlike part 1, this is a heterogeneous situation because the reaction is occurring at specific spatial points (in chamber A & B).

Again, boundary conditions are especially important because the cells line the walls of the cloverleaf shape. This time, however, we will be using Neumann's because there is a known flux (500 umol/um^2 s). Since A is secreting IL-10, we know that there is a positive flux from the boundary in chamber A only. This diffuses normally into all 3 of the other chambers. C & D chambers are inert so nothing else happens, but in chamber B IL-10 is consumed at a rate of 90 um/s.

Here are the respective boundary conditions:

Chamber A:
G (flux) = 500 umol/um^2 q (transfer coefficient) = 0

Chamber B:
G (flux) = 0 q (transfer coefficient) = 90 um/s

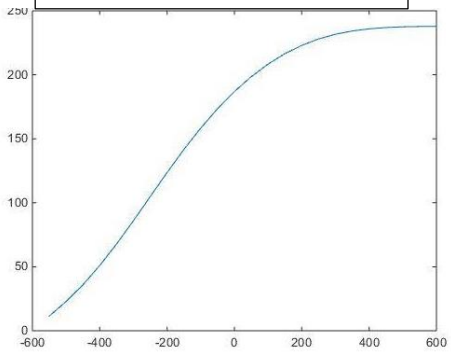
Chamber C & D:

G (flux) = 0 q (transfer coefficient) = 0

Then, using the same elliptical settings in PDE parameters for the reasons stated in part 1.

D (diffusion coefficient) = 10^3 um^2/s **Q = 0** (no overlaying reaction for all **4** chambers so keep it at zero and specify the reactions at the boundary conditions)

Here is the X 1D plot



To get the 1D plots, I exported the data from mesh (for X,Y coordinates) and then used the function TriScatteredInterp (this interpolates data from 3D graphs) which gives you a result F. For the x plot, you would plot x against the resultant vector F. For y plot, plot y against resultant F.

As we can see, the concentration increases from left to right (going from 0->250). This makes sense because Chamber B is on the left and it should have the lowest concentration since it is consuming IL-10.

In the Y plot, the concentration goes from medium to the highest concentration. This makes sense because the C chamber has medium concentration (from diffusion) and A chamber should have the highest concentration because IL-10 is produced there.

Here is the Y 1D plot