Tutorial 8

Using your Cuda file from last week:

- Save your code from last week (tutorial_7.cu) to a new file called tutorial_8.cu
- Update the initial conditions to match the diagram below:

This weeks goal is to modify the code to solve for Temperature using the thermal diffusion equation with FTCS:

$$\frac{\partial T}{\partial t} = \alpha \nabla^2 T$$

Where alpha - the thermal diffusivity – in our case depends on location (i.e. uses the body value):

- Body = 0: Steel (alpha = 18.8 mm^2/s)
- Body = 1: Silver (alpha = 165 mm^2/s)

To remind you, the update formula for FTCS in this case for cell [i,j] is:

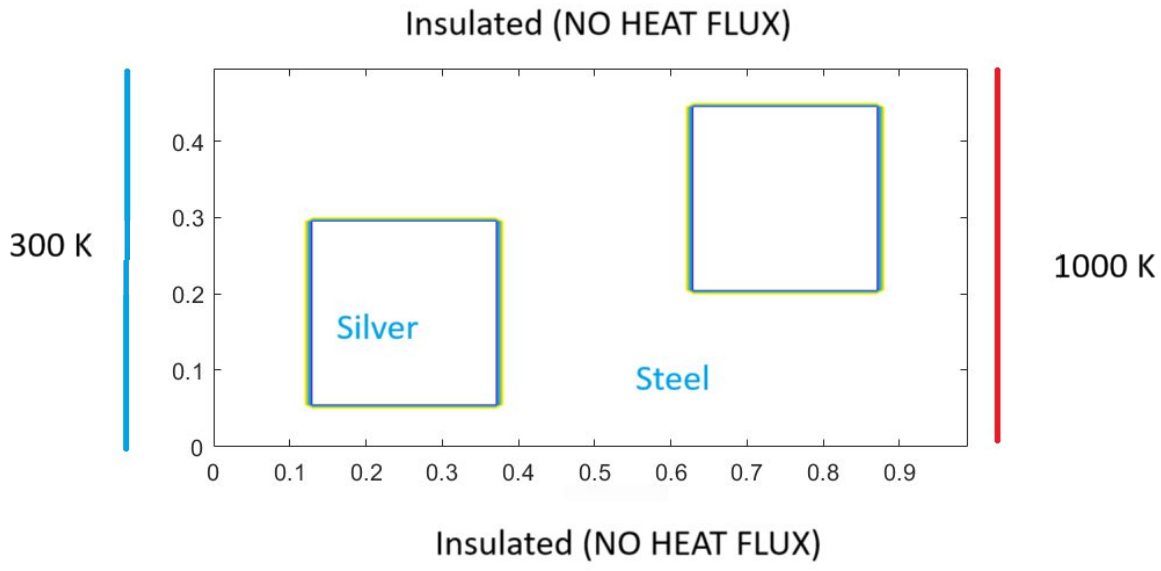
$$T_{new}[i,j] = T[i,j] + \frac{\Delta t \alpha_R}{\Delta x^2}\left(T[i+1,j] - T[i,j]\right) - \frac{\Delta t \alpha_L}{\Delta x^2}\left(T[i,j] - T[i-1,j]\right)$$

$$+ \frac{\Delta t \alpha_U}{\Delta y^2}\left(T[i,j+1] - T[i,j]\right) - \frac{\Delta t \alpha_D}{\Delta y^2}\left(T[i,j] - T[i,j-1]\right)$$

And the alpha values are:

$$\alpha_R = 2\left(\frac{1}{\alpha[i+1,j]} + \frac{1}{\alpha[i,j]}\right)^{-1} \quad \alpha_L = 2\left(\frac{1}{\alpha[i-1,j]} + \frac{1}{\alpha[i,j]}\right)^{-1}$$

$$\alpha_U = 2\left(\frac{1}{\alpha[i,j+1]} + \frac{1}{\alpha[i,j]}\right)^{-1} \quad \alpha_D = 2\left(\frac{1}{\alpha[i,j-1]} + \frac{1}{\alpha[i,j]}\right)^{-1}$$



The boundary conditions are as shown in the figure above:

- The right hand side is fixed at 1000 K.
- The left hand side is fixed at 300 K.
- The top and bottom edges are insulated – no heat flux.

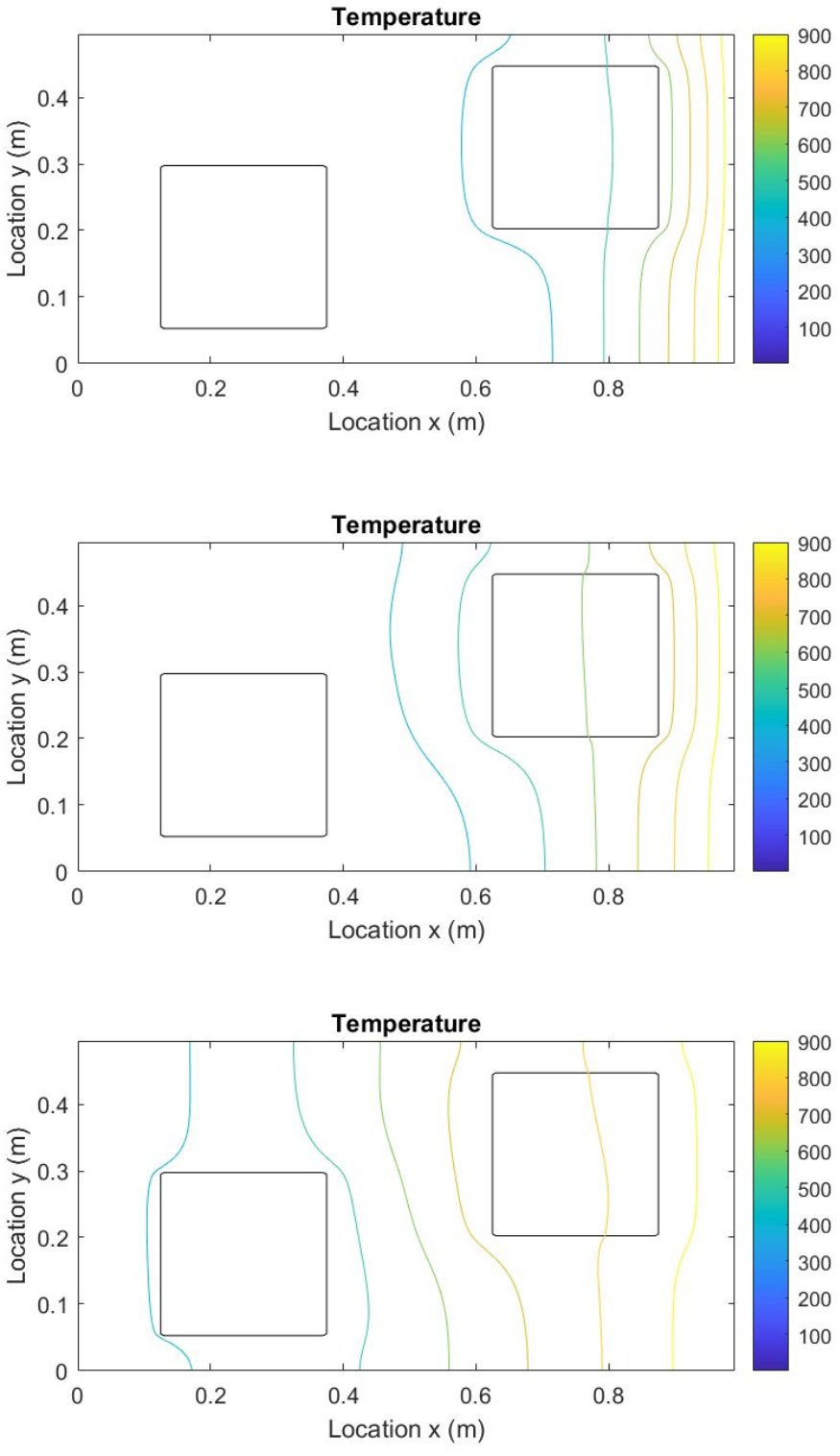
The goal of this week's tutorial is to:

- Update last's weeks code to solve for the temperature after N time steps.
  - Use N = 400,000 time steps.
- You should use the CPU to perform the computation.
  - If you feel ready to use the GPU, please attempt it.
- Your code should save the results in a file (results.txt) which contains the following columns:
  - X
  - Y
  - Body
  - T
- Save your file (Tutorial_8.cu) in a folder called Tutorial_8, and make sure a makefile is included.

You should use DT = 0.02 seconds for your computations, and compare your results to those shown below.

Hints

- The 2D FTCS method you may use is demonstrated in this file: https://github.com/archembaud/NCKU-Parallel-GPU/blob/main/A_4_2D_FTCS/FTCS_2D.m
- You should continue to use a 1D array to store your 2D data, as done in the previous tutorials.



Temperature profile after 1000 seconds (top), 2000 seconds (middle) and 8000 seconds (bottom).