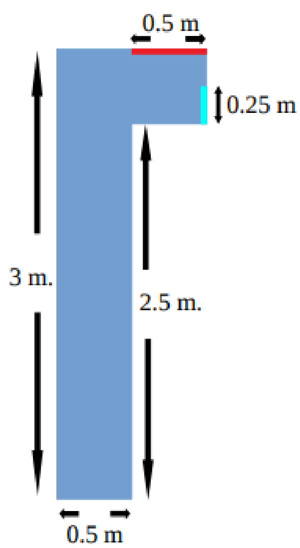
PDE project

Project description,

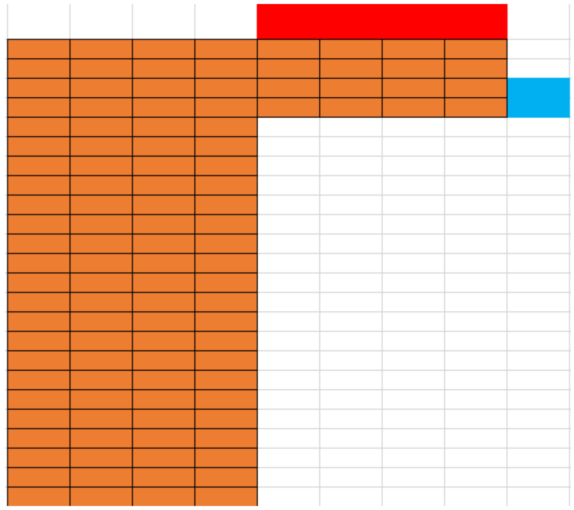
Solve 2-D transient heat transfer problem by using python programming language and necessary libraries. Use backward finite difference scheme in time to solve for temperature at each time step.



Initial condition for all sub-problems is that initially every location (except the constant temperature boundary condition portion) has the temperature of 50 degree C. Boundary conditions: All edges have the perfect insulation boundary conditions (no heat loss), except the edge with red and light blue (teal) color. The edge with red color is the constant temperature boundary of 100 degree C (stay at 100 C all the time). The edge with light blue (teal) color is the constant temperature boundary of 0 degree C (stay at 0 C all the time). The material for heat conduction is copper (use material property values as defined in class for copper).

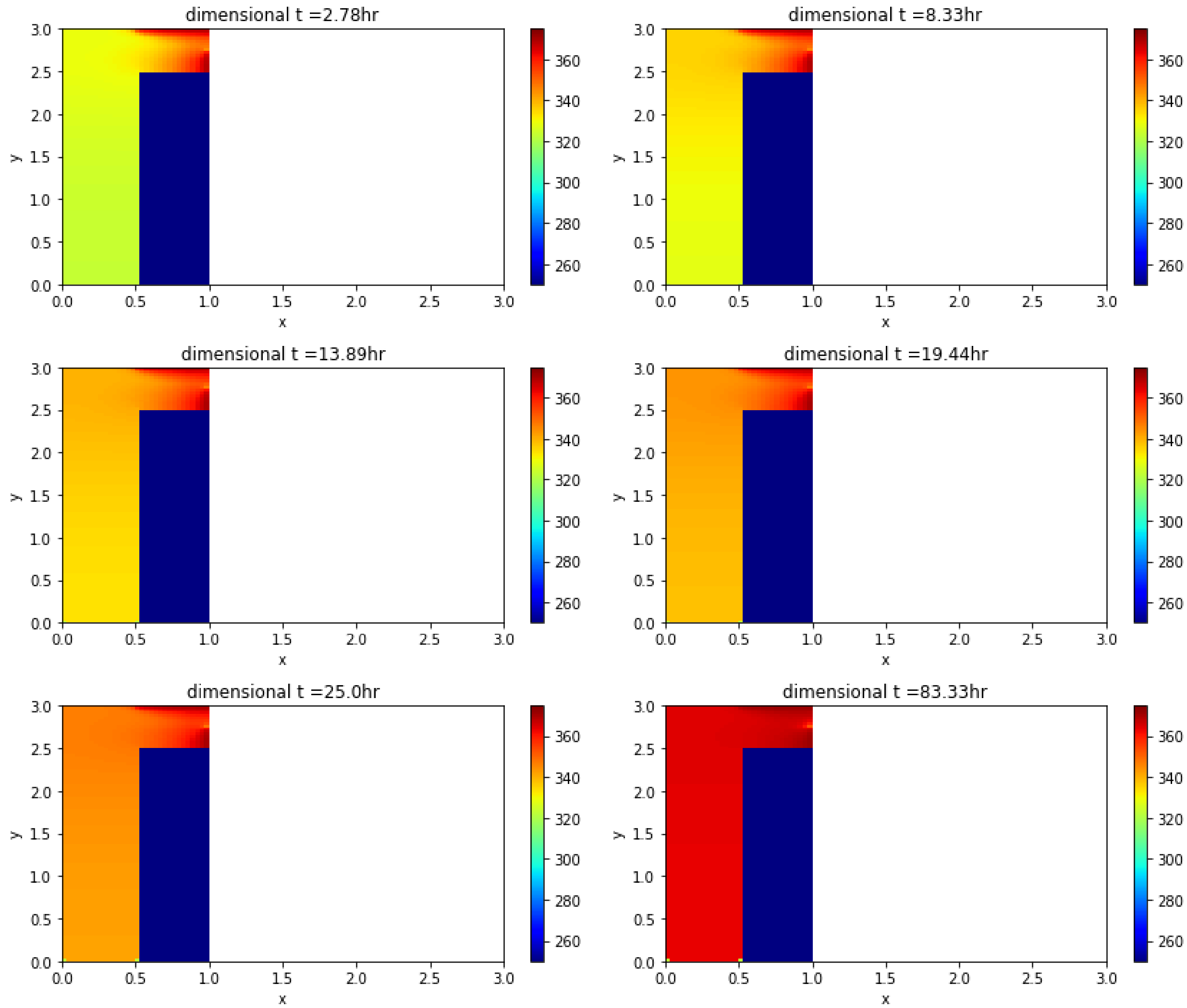
Solution:

The path that I chose was to the actual shape and discretize it. The grid sizes were equal all over the shape in y and in x directions. In first step, I chose the following discretization and drove the coefficient matrix:

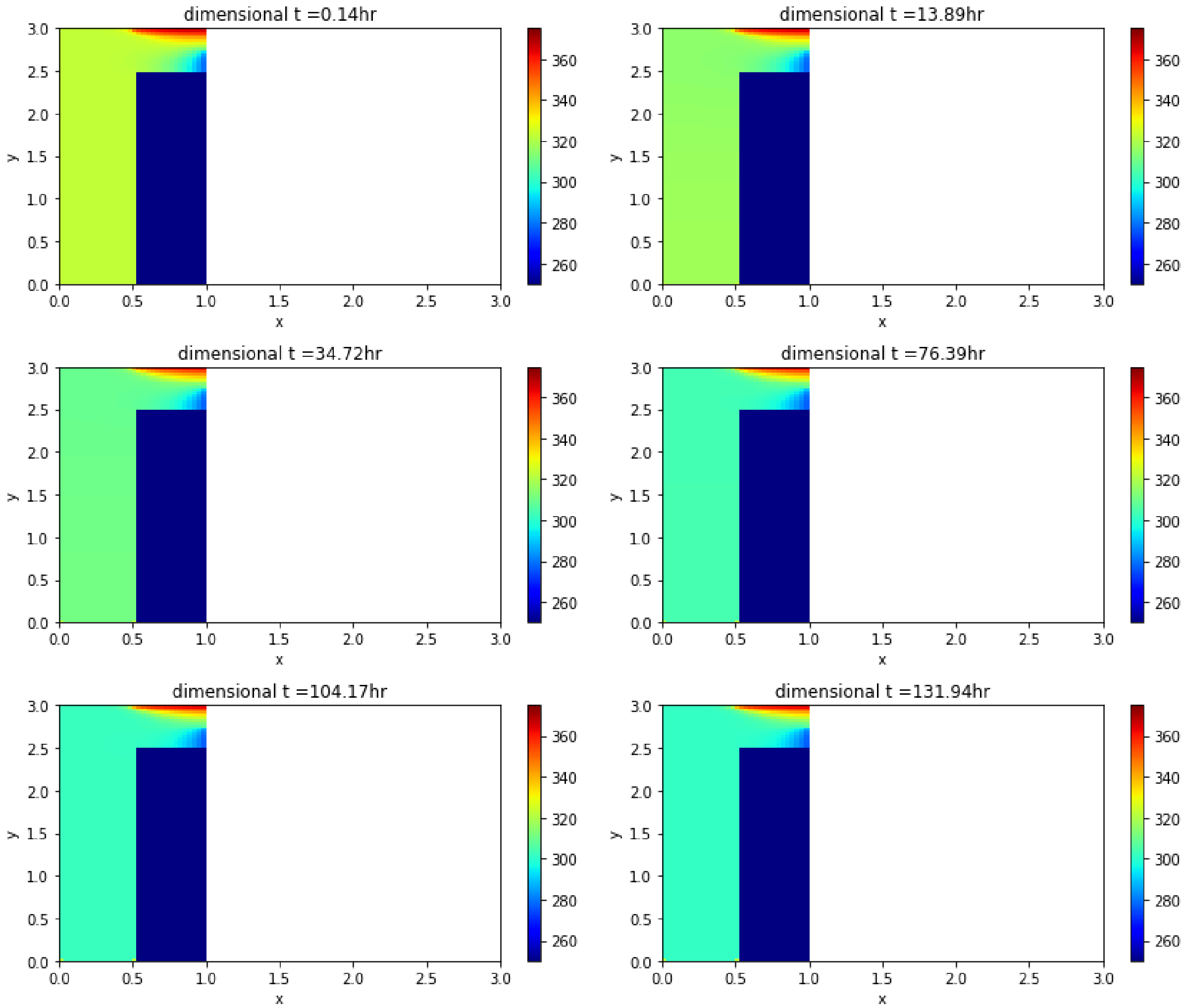


The coefficient matrix was made for each of the points in the above discretization in EXCEL. And an unknown patter was detected. Please go to the EXCEL file for the coefficient matrix. Please note that the detected patters has been noted in the matrix by different colors.

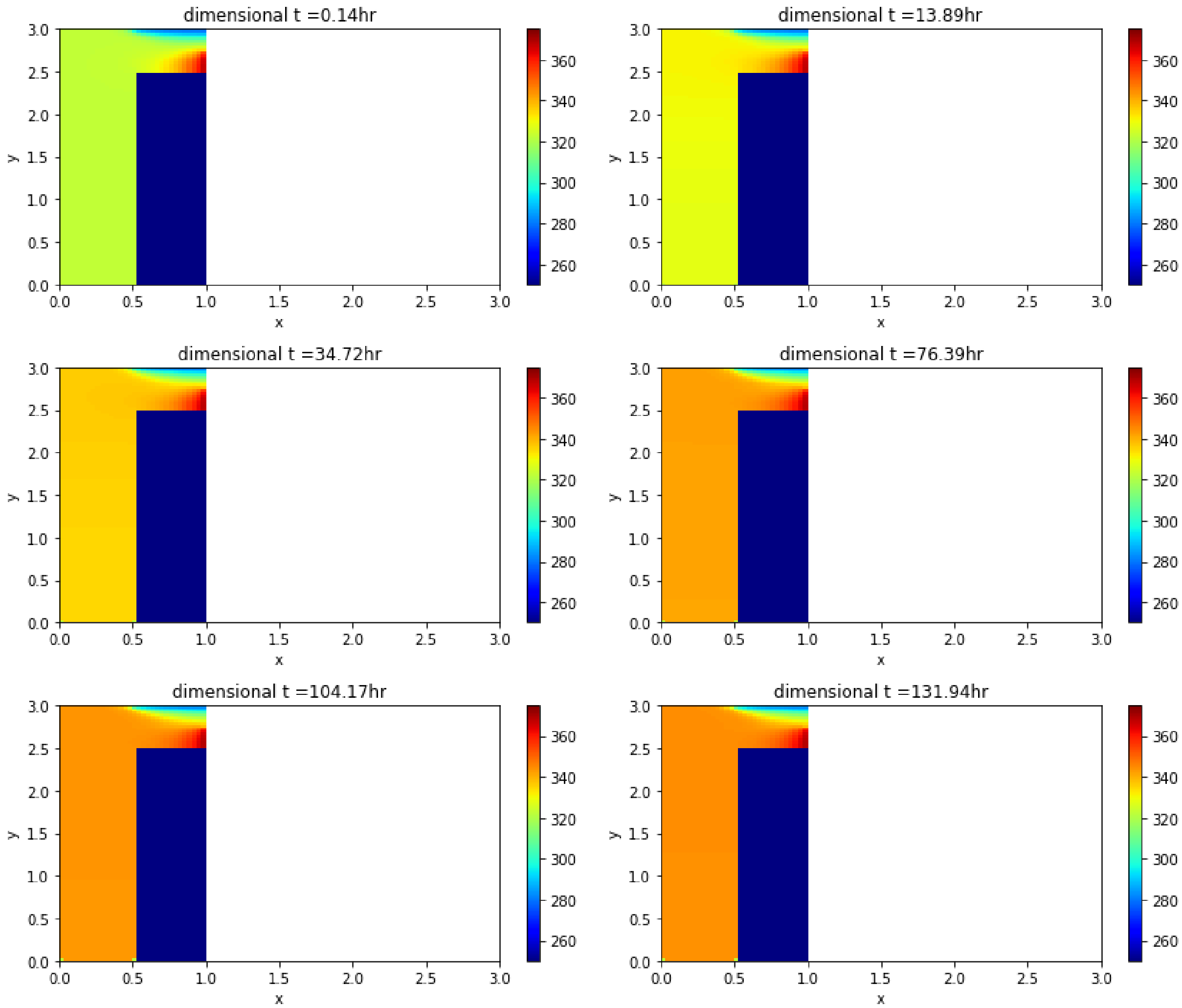
After solving for such discretization, the code was automated for different grid sizes. Afterwards, the results were obtained. The validity of the code was proven by showing an initial case of hot boundaries (the same location as given). The following results were obtained. Please note that the grid size dx=0.03125 and dt is 10 seconds.



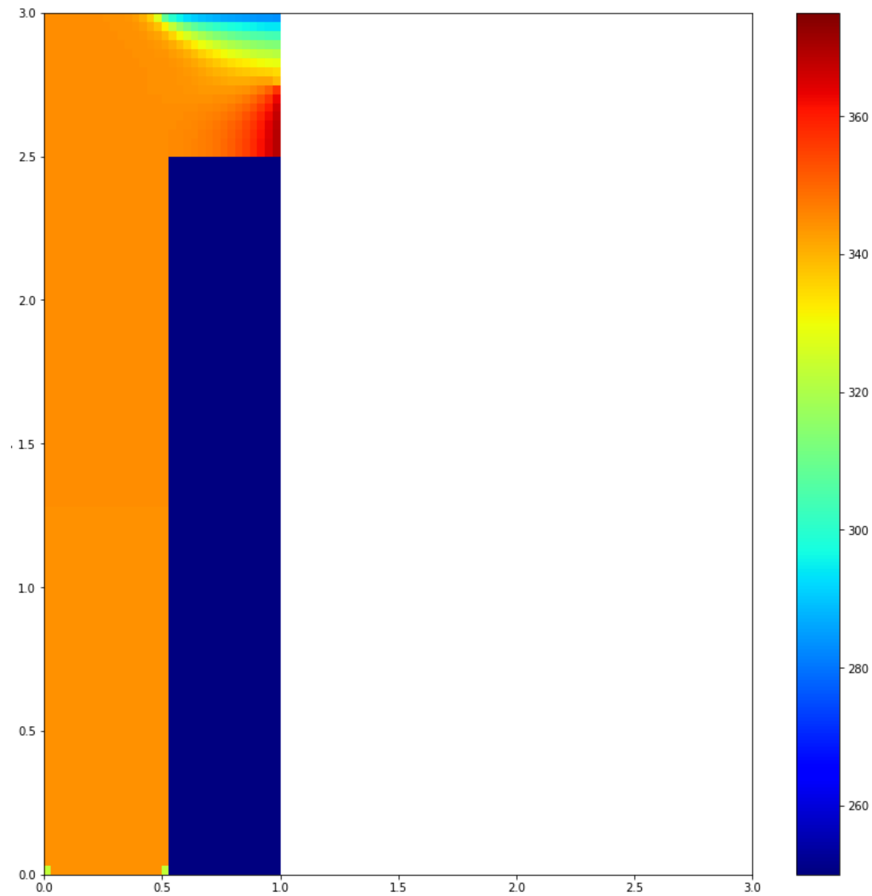
The above graph is a verification of expected behavior of heat propagation. So, in the next step, the actual boundary conditions were set and the following graph has been obtained (dx=0.03125 and dt is 5 seconds)



The hot boundary side was longer than the cold section however, the results show that temperature goes down throughout the shape. Due to this behavior, I decided to perform another case where the location of cold and hot boundaries have been changed. The following results also confirm that the location of the boundary matters when hot and cold sections have been changed.



The following picture is a closer look at t=131.94hr:



3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
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2.5
3.0
360
340
320
300
280
260