CS-302 Modeling and Simulation
Lab-7
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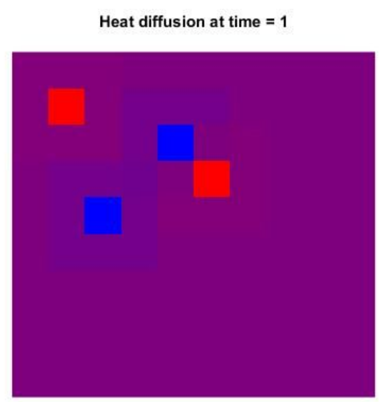
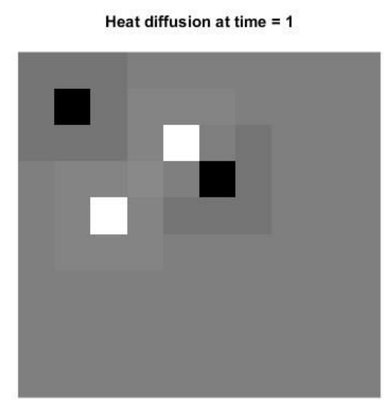
Problem 1:

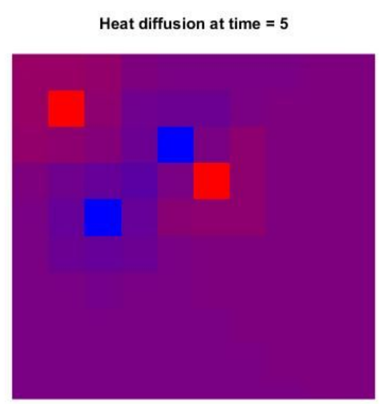
1. a. Determine how long it takes, t, for the bar modeled in this module to reach equilibrium, where from time t to time t + 1 the values in each cell vary by no more than plus or minus some small value, such as ±0.001.

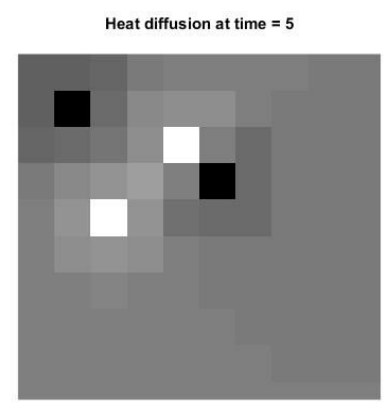
⇒

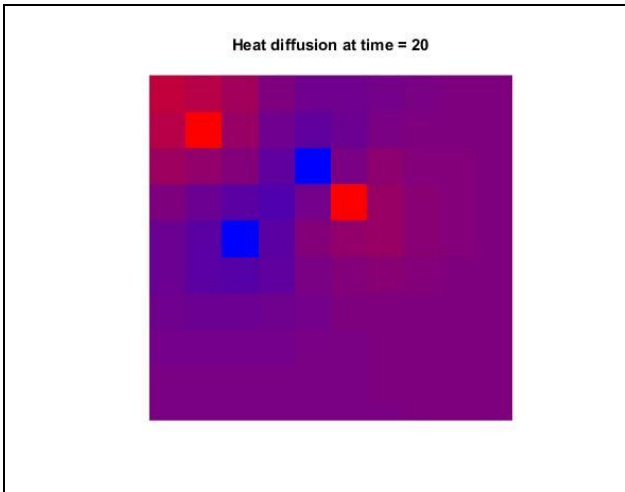
For diffusion rate = 0.05 , 337 iterations are needed. We’ve set the grid size to 10*10.

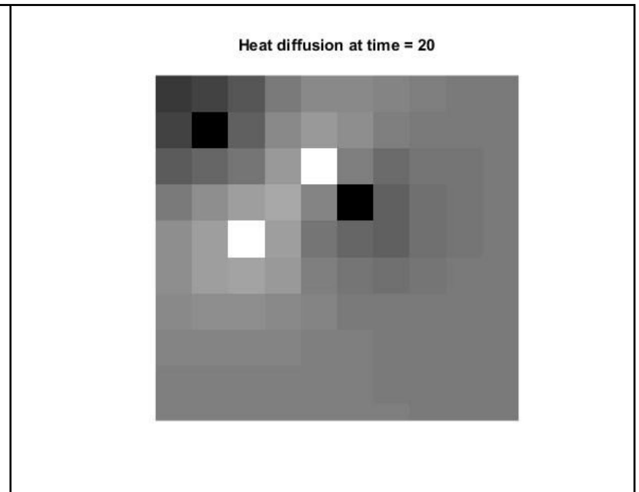


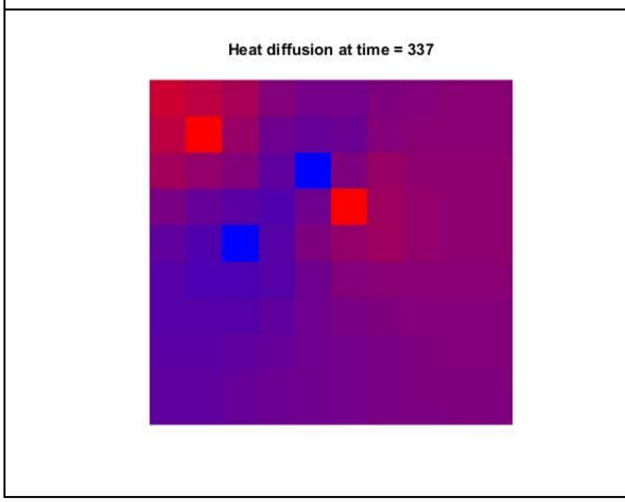


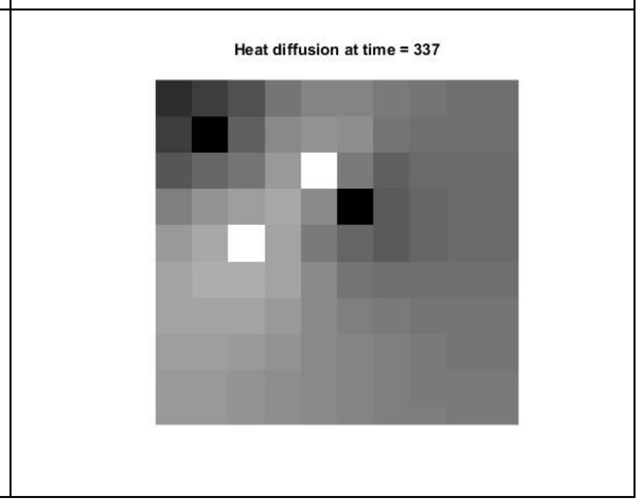






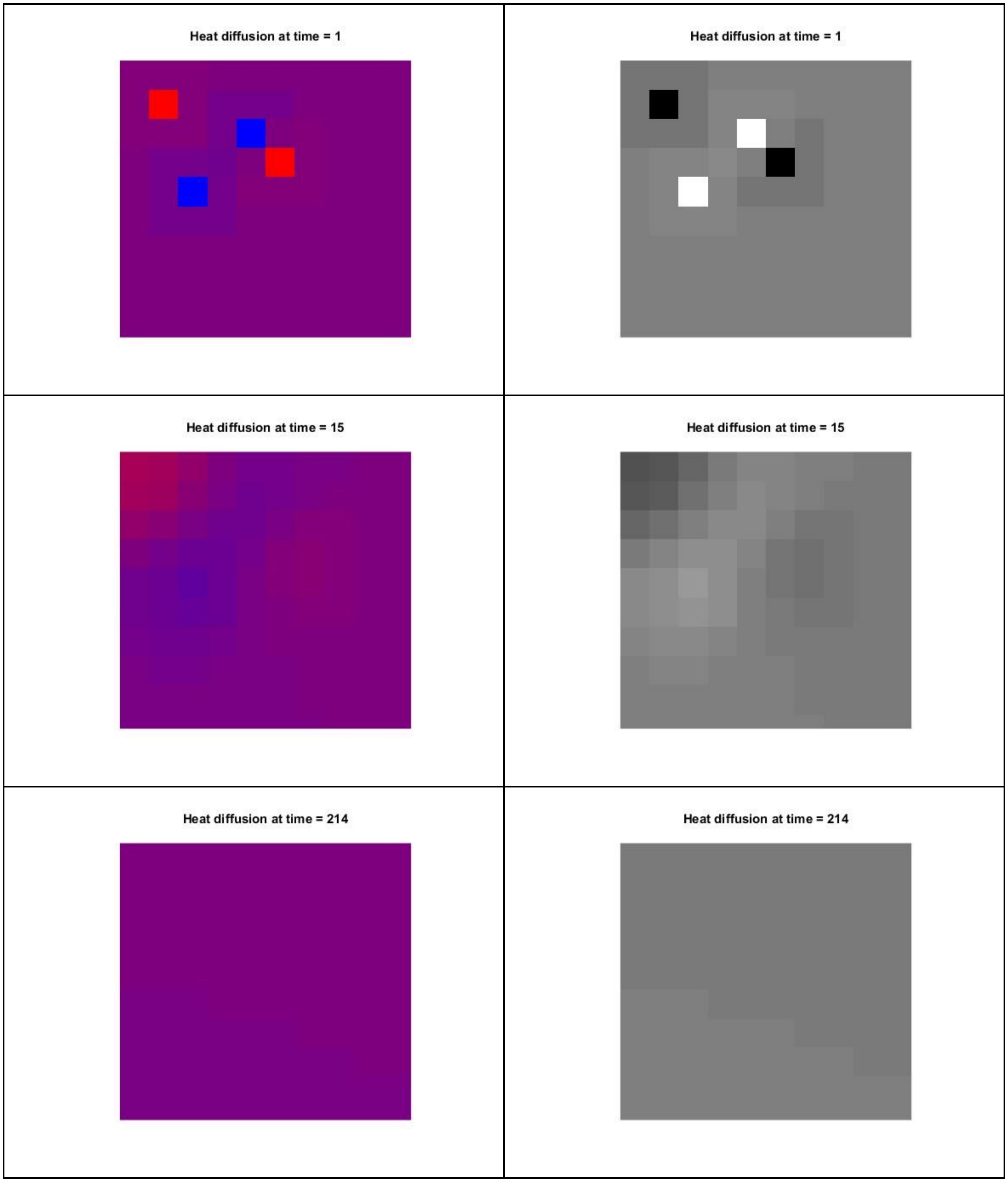






After 337 iterations, the absolute change in each cell is less than 0.001.

b. Repeat Part a, applying heat and cold for 10 time steps and then removing such heating and cooling.



After 214 iterations, the absolute change in each cell is less than 0.001.

Problem 3:

Instead of using the formula for diffusion in the section “Heat Diffusion,” employ the filter in Fig 1. Thus, to obtain the value at a site for time
t + 1, we add 25% of the site’s temperature at time t, 12.5% of the north, east, south, and west cells at time t, and 6.25% of the corner cells to the northeast, southeast, southwest, and northwest. This sum is called a weighted sum with each nutrition value carrying a particular weight as indicated by the table. Revise the model using this configuration and compare the results with that of the module.

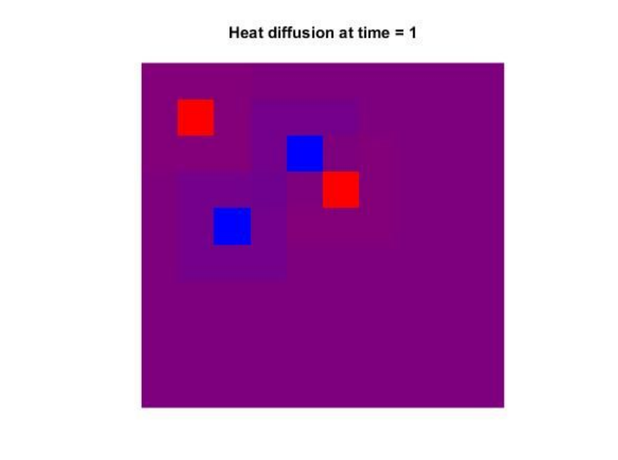
0.0625	0.125	0.0625
0.125	0.25	0.125
0.0625	0.125	0.0625

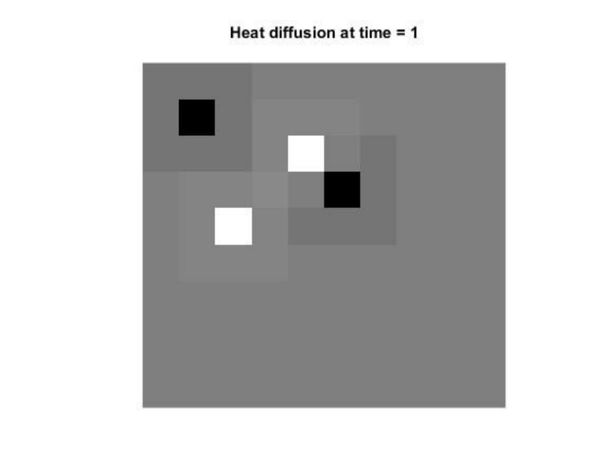
Fig1 - Filter for project 3

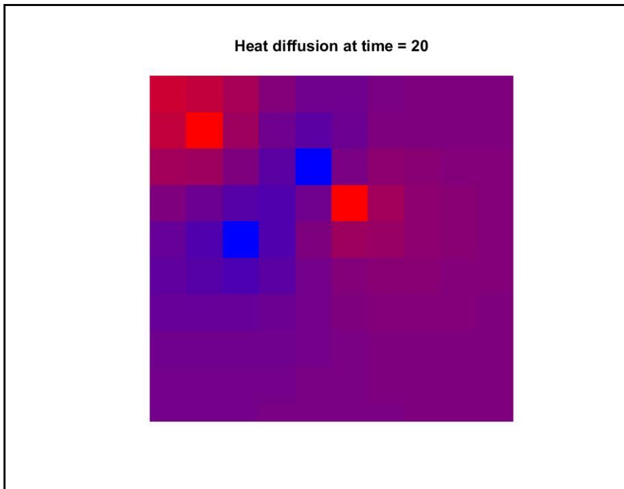
[Link to Color simulation]
[Link to Gray simulation]

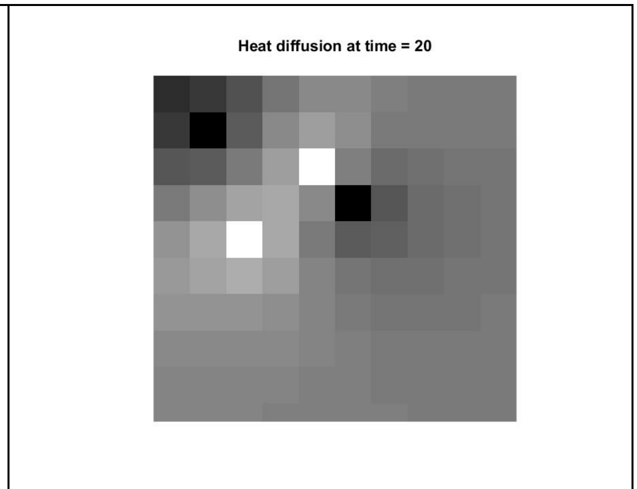
Case - 1

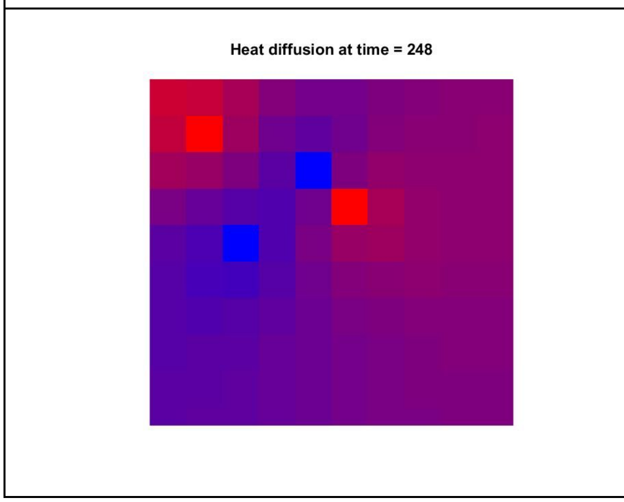
Apply heat cold at every step:

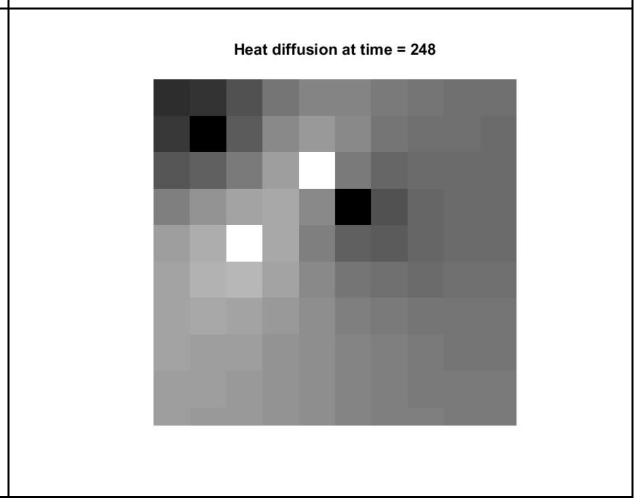




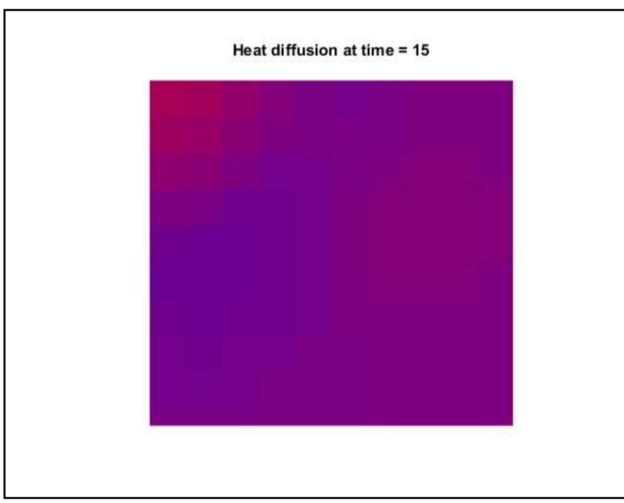


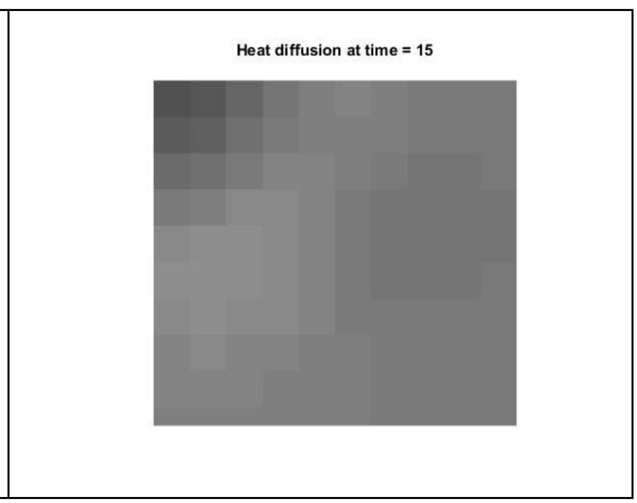


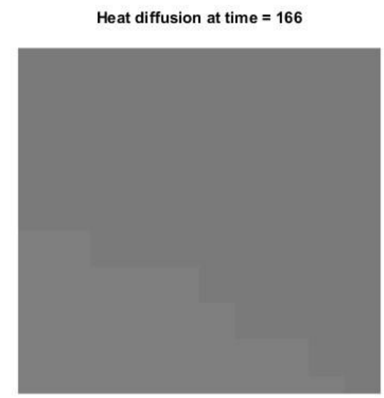




Case - 2
Stop applying heat cold after 10 steps:







Comparison:

Time to reach steady state (Absolute difference less than 0.001):

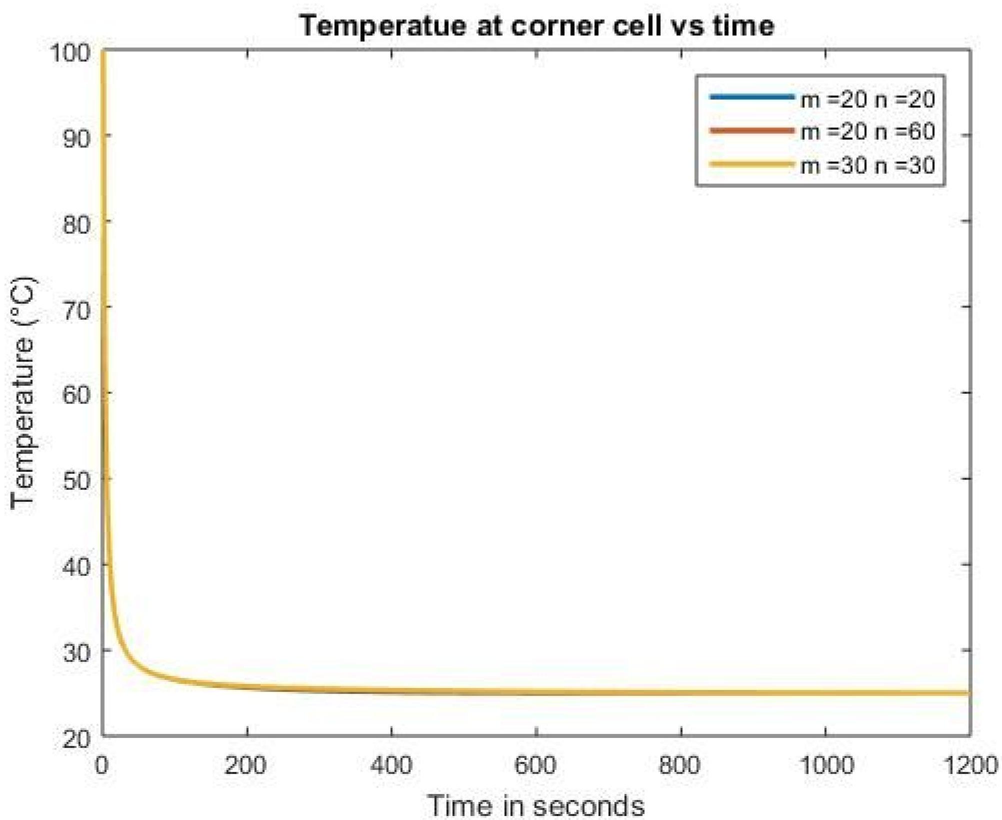
	Formulae - 1	Formulae - 2
Apply heat cold at every step	337	248
Stop applying after 10 steps	214	166

Here we can see that the second formula is based on averaging of the states. So, it tends to “average out” faster and that is why it reaches steady state faster.
It is obvious that if we stop applying heat and cold method then the steady has to achieve in less time stamps because the constant driving force is now not there.

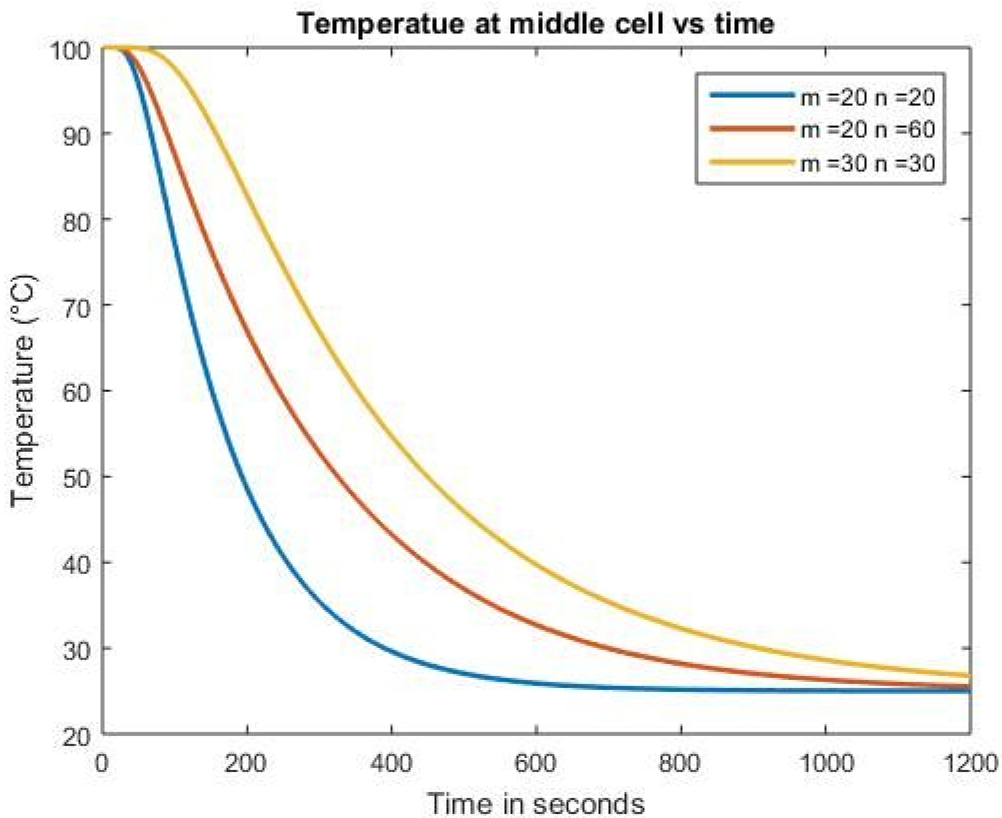
Problem 4 :

a. Model a bar at 100 °C that has a constant application of a 25 °C external source on its boundary. Generate plots of the temperatures at a corner and in the middle of the bar versus time. Describe the shapes of the graphs.

Corner cells will have constant temperature of 25 °C after very short time. So it's plot will be exponential decay with fast decay rate.



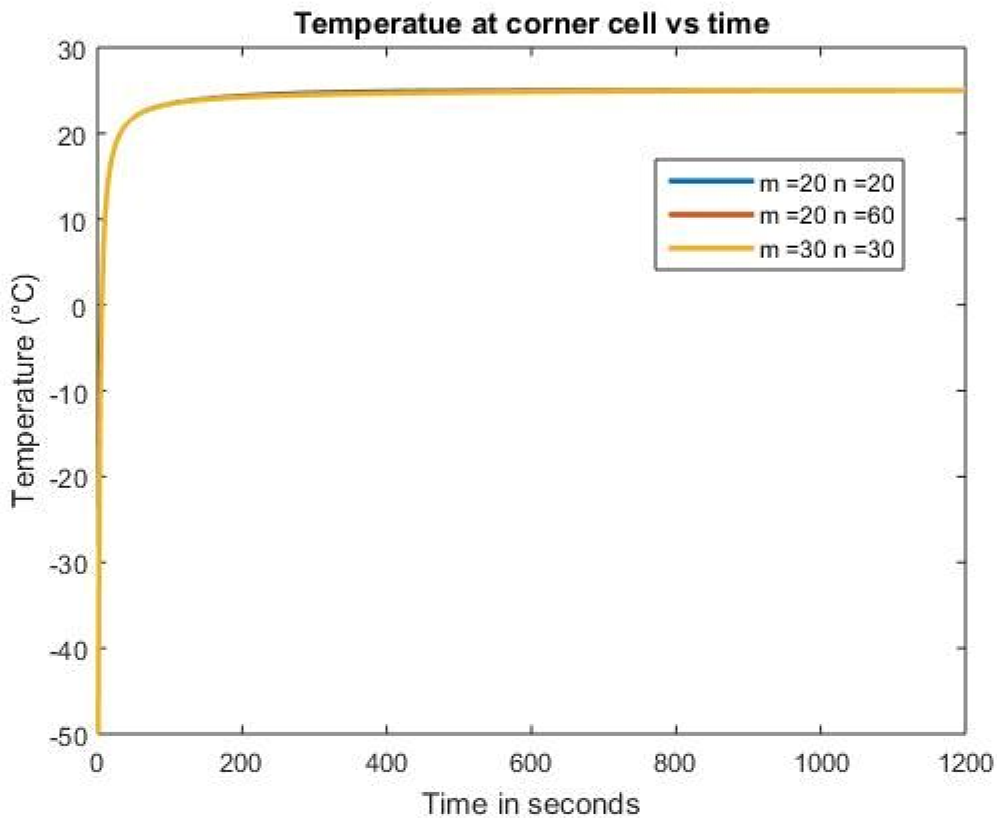
For the middle cell (m/2, n/2), initial temperature is 100 °C. As the time passes temperature eventually comes down to 25 °C due to heat diffusion due to the cold boundary cells. The plot of temperature vs time is similar to that of exponential decay.



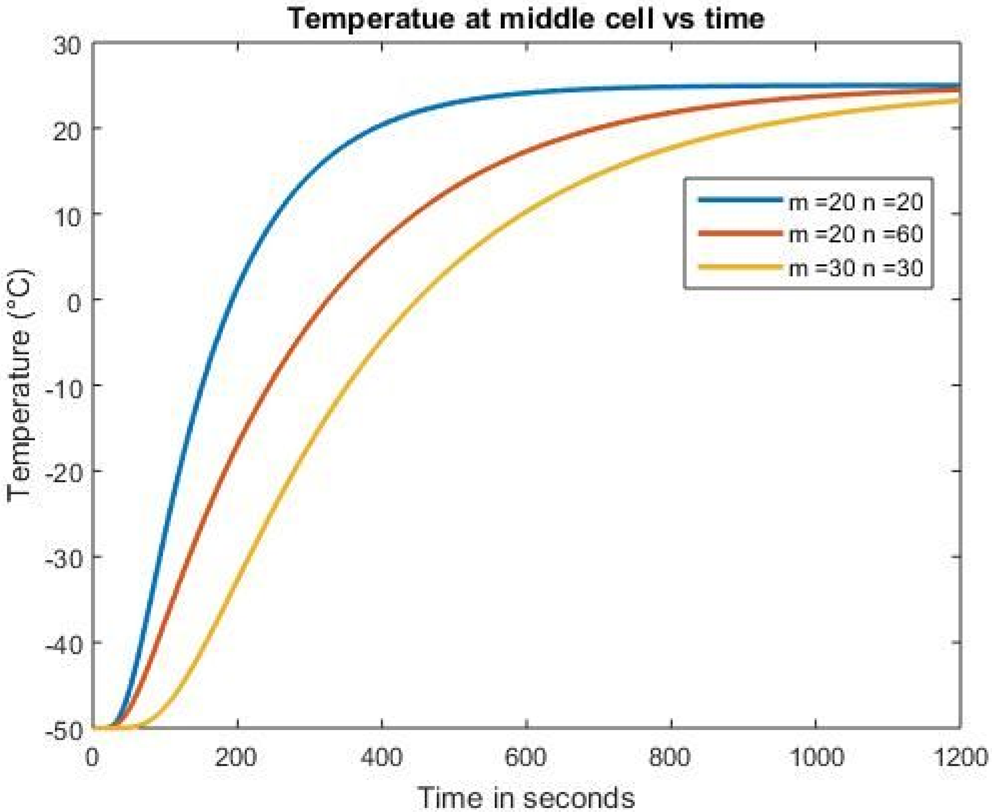
Temperatue at middle cell vs time
m =20 n =20
m =20 n =60
m =30 n =30
Temperature (°C)
100
90
80
70
60
50
40
30
20
0
200
400
600
800
1000
1200
Time in seconds

b. Repeat Part a with the bar being at –50 °C.

Corner cells will have constant temperature of 25 °C after very short time. So it's plot will be exponential growth with fast growth rate.

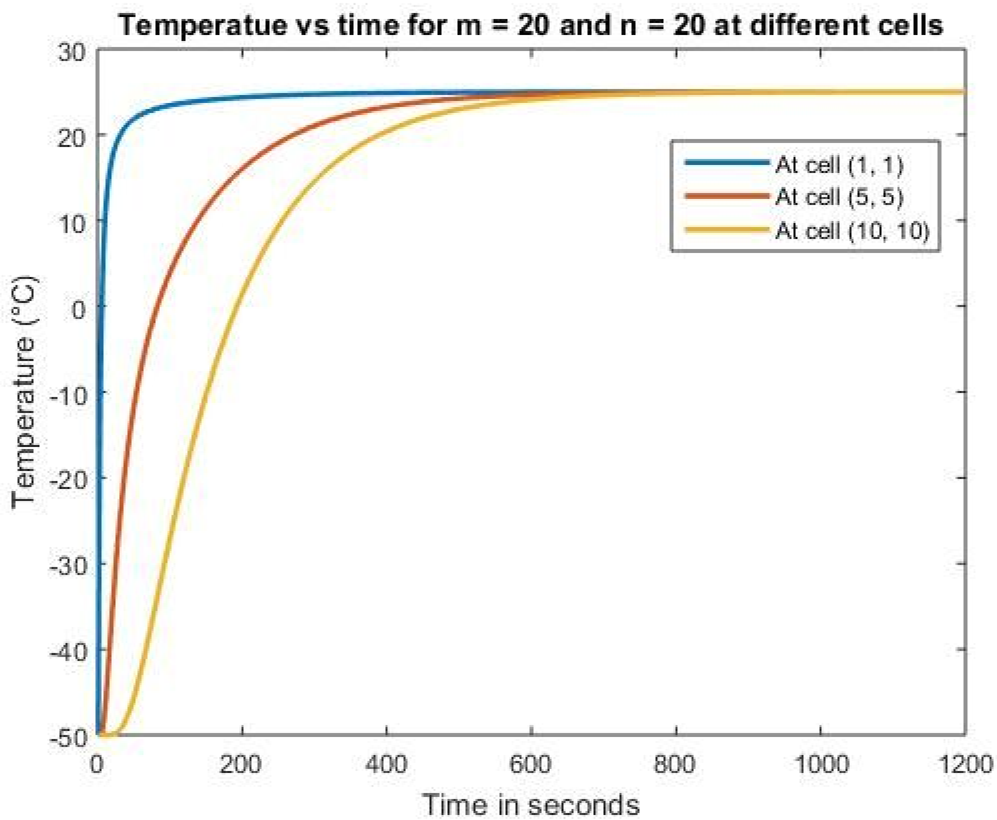


The plot for temperature vs time for middle cell will be similar to that of exponential growth. The final temperature reached will be 25 °C.



Temperatue at middle cell vs time
Temperature (°C)
Time in seconds
30
20
10
0
-10
-20
-30
-40
-50
0
200
400
600
800
1000
1200
m =20 n =20
m =20 n =60
m =30 n =30

c. Discuss the results.



The temperature of all the cells will eventually be equal to the external source temperature. The cells near to boundary will reach this temperature faster than the cells near the middle area of bar. If the temperature of constant external source is less than initial temperature of bar then the plot of temperature vs time will be exponential decay with decay rate higher for cells near boundary and less for cells far from boundary. Similarly, if the temperature of constant external source is higher than initial temperature of bar then the plot of temperature vs time will be exponential growth with growth rate higher for cells near boundary and less for cells far from boundary.

Source:

We have only used the **plotting function** available on the Angela et. al.'s website. But, other codes are written by us.