Homework No.2

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What will I achieve?

With this homework you will practice the use of the concepts and knowledge acquired throughout the corresponding topics.

Instructions

1. *Read **problem statement**, and collect the information that may be needed.*

if the system initially is at $25°C$, calculate:

a) How long will it take to reach steady state (i.e. external heat is 98% of the internal heat), and the heat rate as a function of time.

b) Temperature animation within the system for the first $24h$

2. *Make a **Sketch** (Diagram, process flow chart), indicating mass, linear or angular momentum (i.e. forces and torques) and energy interaction, and label each stream and boundaries as well.*

See Figure 6

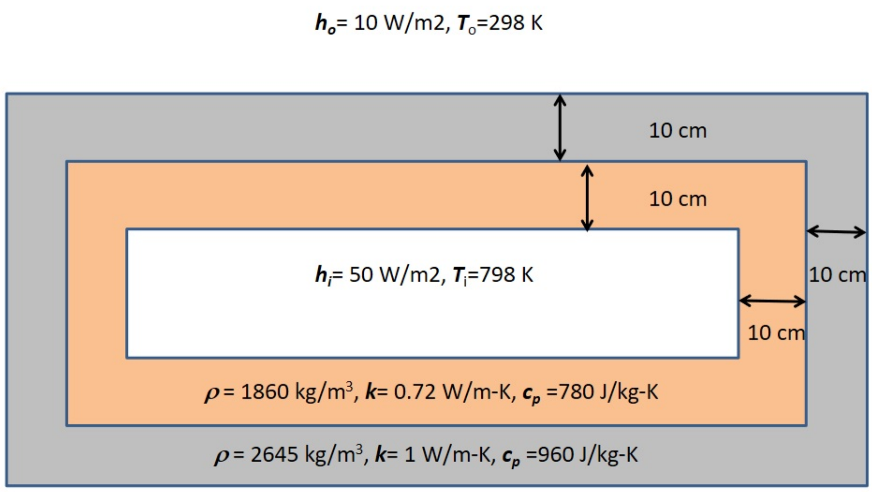


Figure 1: Properties of a chimney: $4m$ long, $1m$ wide, and each wall in $10cm$ thick

3. *List **Assumptions and Approximations** (sometimes they may be inferred by the sketch, but make them explicit) supported by equations if possible (geometric relationships, or fundamental equations).*

- The inner part heat transfer coefficient is $h_1 = 10W/m^2$
- The inner part heat transfer coefficient is $h_2 = 50W/m^2$
- The cold gas outside the chinmey is at a constant temperature $T_1 = 298K$
- The hot gas within the chimney is at a constant temperature $T_2 = 798.15K$
- the initial temperature of the system id $T_{init} = 298K$
- The "grey" wall is $2m$ long and $1m$ wide
- The "orange" wall is $1.8m$ long and $0.8m$ wide
- The "inner cavity" is $1.6m$ long and $0.6m$ wide

4. ***Physical Laws*** *(Fundamental Laws) must be written in full form, and terms can be dropped by the right selection of frame of reference, operating conditions, assumptions, simplifications or constraints.*

Parabolic PDE for heat transfer, as we are interested in the transient temperature

$$\rho c_P T' - div\left(\kappa grad(T)\right) = Q + h(T_{ext} - T) \tag{1}$$

where:
ρ is the density
c_P is the heat capacity
κ is the coefficient of heat conduction
Q is the heat source
h is the convective heat transfer coefficient
T_ext is the external temperature

5. ***Physical constants*** *should be obtained from a reliable source (knowing this information by heart is always helpful), geometric relations and formulae must be included as part of your analysis.*

Not Applicable

6. ***Calculations*** *are done including units. Any algebraic manipulation is recommended in few cases, because limits the step 8, but if needed should be done before using numerical values of constants, properties or variables.*

As in Figure 2, the first step is to draw the geometry of the chimney in the PDE tool in Matlab. The x and y axes limits are set to have a better view. In the "Set formula" field the following is specified: (greyWall+orangeWall)-hotGas. The "Set formula" value is to create the hotGas cavity of the chimney.

The discretization result of the geometry is shown in Figure 3. This is done to show the correct use of "Set formula" and the drawing process. A finer grid will yield better resolution results.

Next step is to specify the type of problem of "Heat Transfer", as shown in Figure 4.

Further, the boundary conditions shall be specified of type Neuman within the PDE tool. These conditions are set by the variables $g = q * T_{of}$ and q, the heat flux and the heat transfer coefficient respectively. T_{of} is the temperature outside the boundary. See 5.

On the other hand, the PDE of type parabolic is specified for each wall using Equation 1.

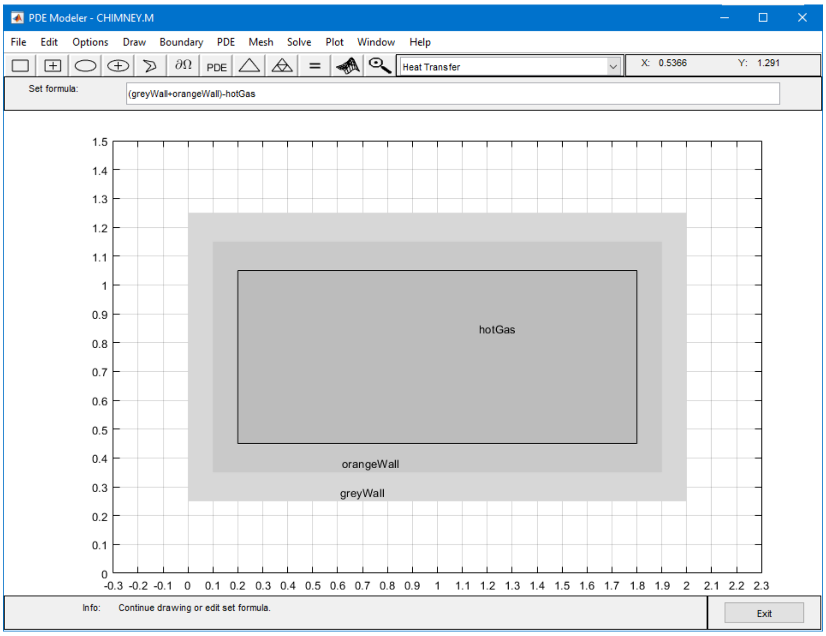


Figure 2: Screen-shot of the drawing step

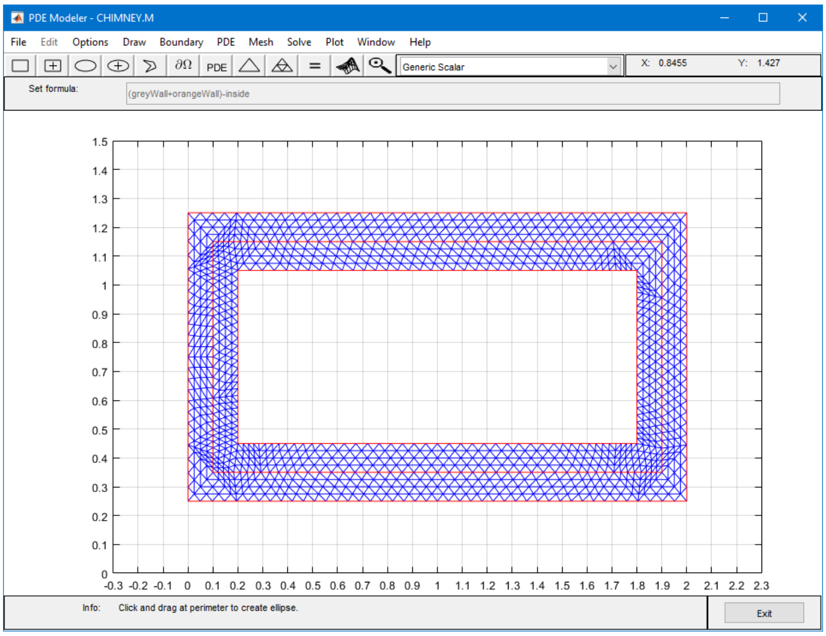
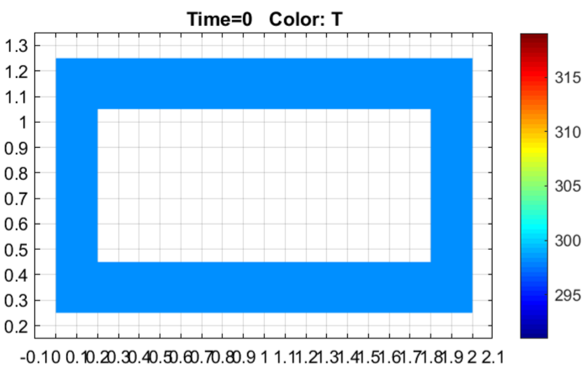
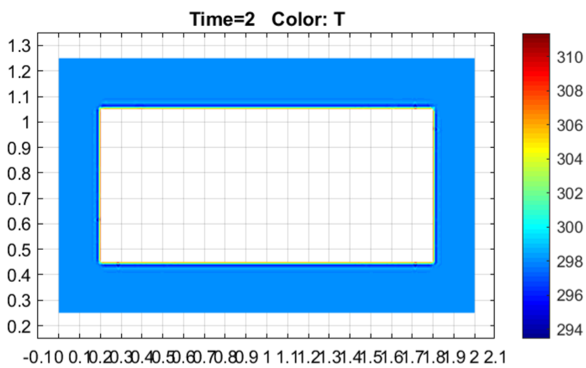


Figure 3: Screen-shot of the drawing step

Finally, the PDE solution is shown in Table 1 at different times. This solution assumes that the initial temperature of the system is of $298K$





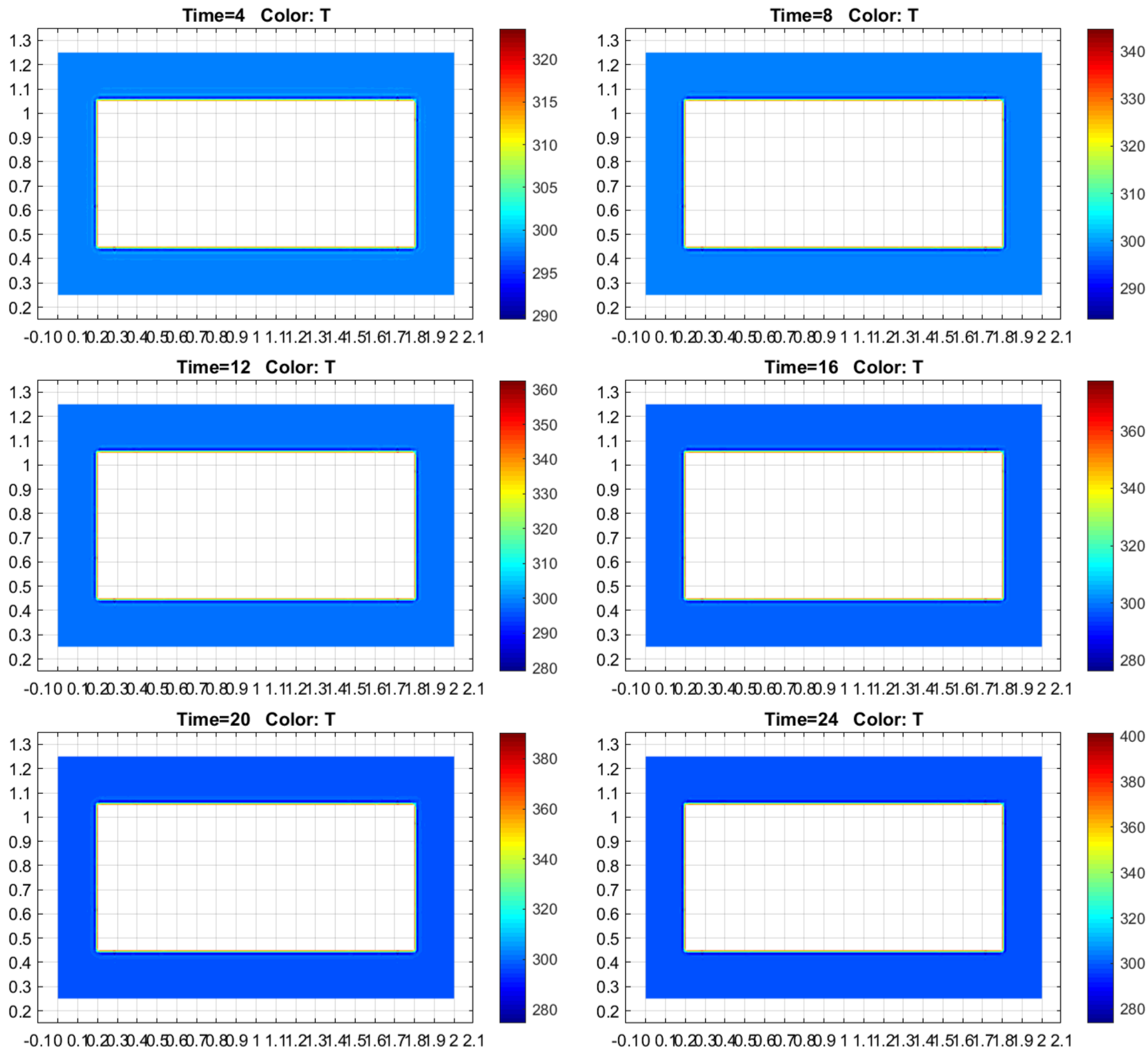


Table 1: Heat transfer animation, where 'Time' is in hours

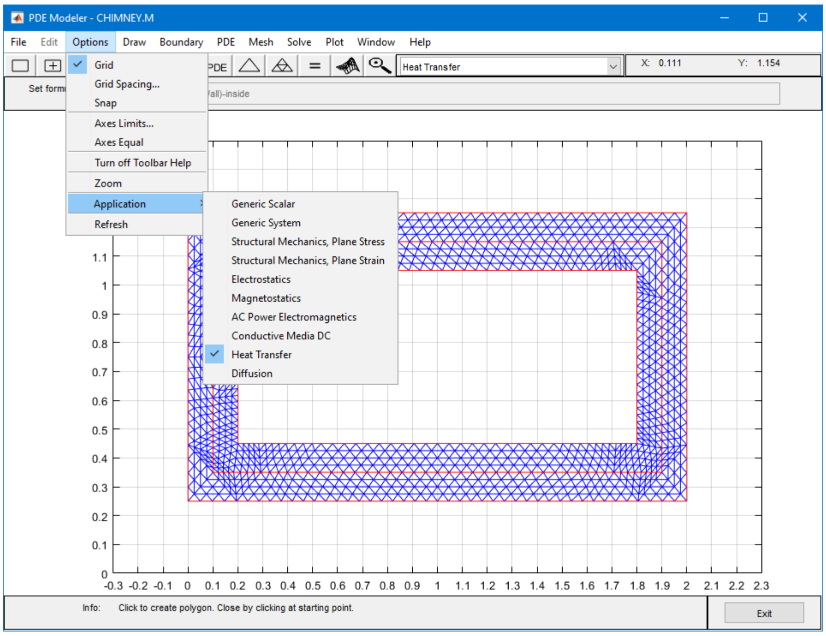


Figure 4: Screen-shot of the drawing step

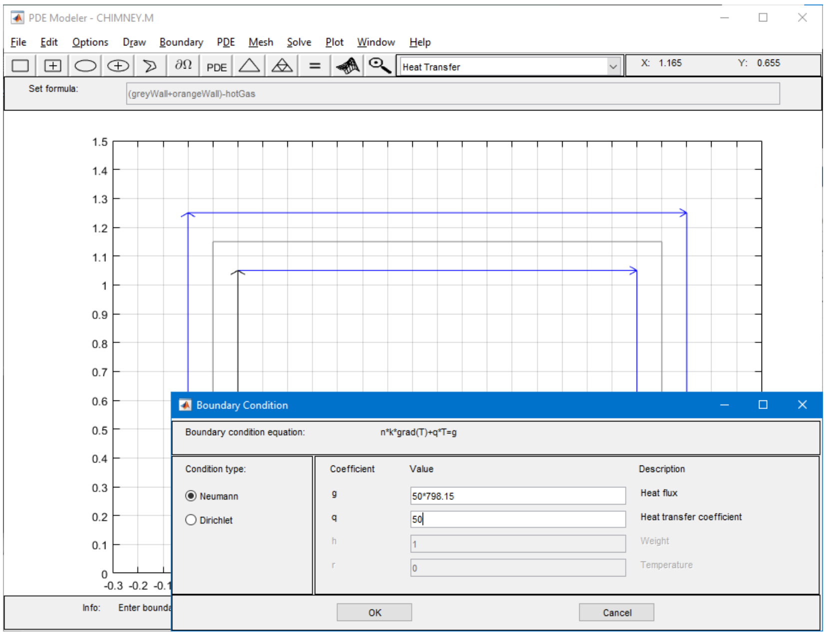


Figure 5: Screen-shot of the drawing step

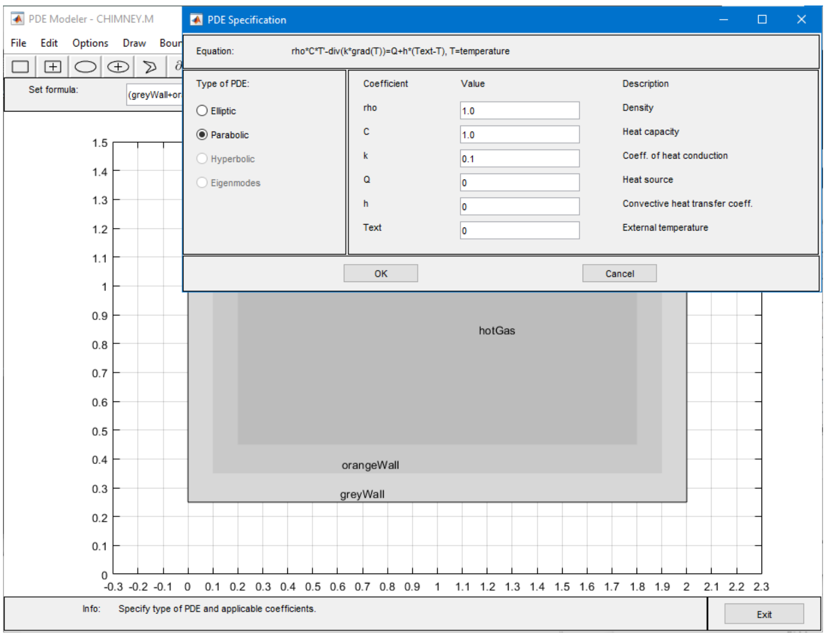


Figure 6: Screen-shot of the drawing step