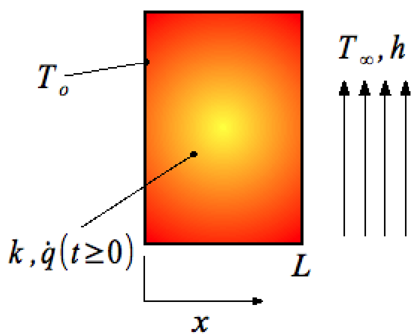
Heat and mass tutorial 2, question 4 animation

Some of you asked me to share the animation that I showed in tutorial 2 and the code to make them. The animations are saved as mp4 in the folder that was zipped. There are 2 matlab files in this folder too. These are the files used to generate the animation.

The file **CHEE315_PDE.m** solves numerically the partial differential equation of the transient 1D heat diffusion with generation problem. You should be able to run it if you have the basic Matlab software. You can change the values of the constants for this question in this file.

The file **CHEE315_animation.m** makes the animations and to generate the answers to part a) and part b). Make sure to use '***Run and Advance***' and not '***Run***'. This will play each section of the code separately so you have more time to observe the figures.

4) A plane wall with constant properties is initially at a uniform temperature T_o. Suddenly, the surface at $x=L$ is exposed to a convection process with a fluid at $T_\infty (> T_o)$ having a convection coefficient h. Also, suddenly the wall experiences a uniform internal volumetric heating that is sufficiently large to induce a maximum steady-state temperature with the wall which exceeds that of the fluid. The boundary at $x=0$ remains at T_o.



1/2

(a) On T-x coordinates, sketch the temperature distributions for the following conditions: initial condition ($t=0$), steady-state condition ($t \to \infty$), and for two intermediate times. Show also the distribution for the special condition when there is no heat flow at the $x=L$ boundary.
(b) On $q''_x - t$ coordinates, sketch the heat flux for the locations $x=0$ and $x=L$.

Assume:

- constant properties
- uniform generation
- $T_o < T_\infty$
- generation term is large enough that $T(L,\infty) > T_\infty$

The heat diffusion equation in Cartesian coordinates reduces too:

$$k\frac{\partial^2 T}{\partial x^2} + \dot{q} = \rho C_p \frac{\partial T}{\partial t}$$

The initial condition is:

$$T(x,0) = T_o$$

The boundary condition on the left is a Dirichlet boundary condition:

$$T(0,t) = T_o$$

The boundary condition on the right is a Neumann boundary condition:

$$q''|_{x=L} = h(T(L,t) - T_\infty)$$

To obtain the graph there is need to give some values to the constants of the problem. To put a number on my variable I decided to imagine the plain wall as being made of AISI 304 stainless steel cubes that have 5 cm sides and each generates 400 Watts because there is a current that is flowing through them. The width of the wall is L = 0.05 meters. The properties of the steel are chosen to be those at 300 K. The convection coefficient value was chosen to give a nice curve.

The property values are:

$$\dot{q} = \frac{400}{0.05^3}\frac{W}{m^3}$$

$$\rho = 7900\frac{kg}{m^3}$$

$$Cp = 477\frac{J}{kg * K}$$

$$k = 14.9\frac{W}{m * K}$$

$$T_o = 0°\text{C}$$

$$T_\infty = 40\ °\text{C}$$

$$h = 1000\frac{W}{m^2 * K}$$