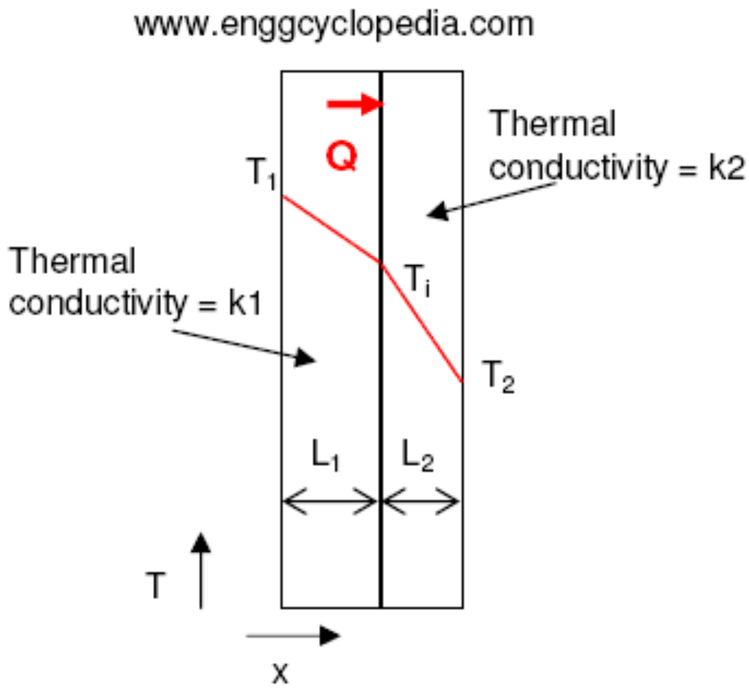
Heat and Mass Transfer (BSEN 2240)

This course helped me to have a better understanding of many heat and mass transfer applications. Prior to taking this course I did not have the greatest understanding of the thermal conductivity coefficient, the Biot number, or the Nusselt number. This course not only helped me understand those concepts, but I am now able to calculate the conductive, convective, and radiative heat transfer, calculate the convective heat transfer coefficient, determine if convection is forced or natural, calculate the velocity and thermal boundary layer thickness, and much more.

Regarding the thermal conductivity coefficient, k, I learned that a lower k-value corresponds to a steeper temperature slope. This means that the material is a good insulator and a poor conductor, as it takes longer for the material to reach a temperature equilibrium. Alternatively, a higher k-value indicates a lower temperature gradient and means the material is a good conductor and a poor insulator, as the material with the higher k-value would reach a temperature equilibrium faster. For the example shown below, k1 > k2, based on the slopes, making k1 a good conductor, such as a metal, and k2 a good insulator, such as wood or glass.



As for the Biot number, I now understand that it is a ratio of internal conductive resistance to the external convective resistance. The Biot number is used for transient heat transfer in order to determine what method you can use to solve for the heat transfer. The Biot number has this function because if it is very small, that means that the external convective resistance is very large, or at least much larger than the internal conductive resistance, and that internal conductive resistance can be assumed to be negligible. In that case, you can then use the lumped analysis. Otherwise, when the Biot number is very large, the internal conductive resistance cannot be assumed to be negligible, and so we have to use the graphs correlating to different shapes.

$$\boldsymbol{Bi = \frac{hL}{k}}$$

The lumped capacitance method equation, for use when Bi >>0.1

$$\frac{\theta}{\theta_i} = \frac{T - T_\infty}{T_i - T_\infty} = \exp\left[-\left(\frac{hA_s}{\rho V c}\right)t\right]$$

The Nusselt number is the ratio of convective to conductive heat transfer in a fluid, and due to the numerous Nusselt number equations involving other dimensionless numbers, it is often used to calculate the convective heat transfer coefficient. The Nusselt number is essentially the Biot number, but for fluids instead of solids, so it is still applied to a transient system, however the “k” for the equation must be the thermal conductivity of the fluid.

$$\boldsymbol{Nu = \frac{hL}{k}}$$