

MEAM 333: Heat and Mass Transfer
Assignment 7
Due Date: 2/14/2012

Homework Guidelines:

- All papers must be stapled (No dog eared pages!).
- Solutions must proceed in a step-by-step fashion so that it is easy for the grader to follow and the method is well explained.
- Handwriting should be neat and presentation should be professional.
- Final answers for each part should be boxed or double underlined.
- Failure to do the above will result in point deductions.

Problem 1 [Solution]:

A thin metallic wire of thermal conductivity k , diameter D , and length $2L$ is annealed by passing an electrical current through the wire to induce a uniform volumetric heat generation \dot{q}''' . The ambient air around the wire is at a temperature T_∞ , while the ends of the wire at $x = \pm L$ are also maintained at T_∞ . Heat transfer from the wire to the air is characterized by the convection coefficient h .

Part A: Assuming that the temperature varies only with the position, x , along the wire, obtain an expression for the steady-state temperature distribution $T(x)$ by doing the following:

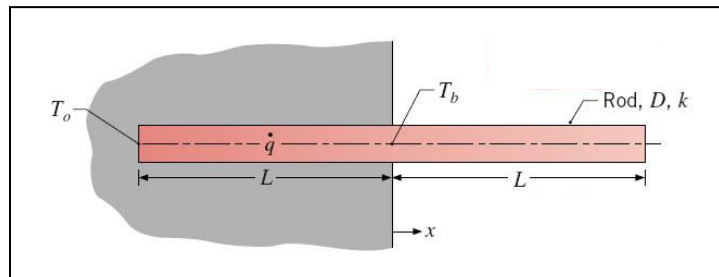
1. Perform an energy balance on a differential slice of the wire
2. Obtain a differential equation from the energy balance on the differential slice
3. Use the boundary conditions to solve the differential equation and write down your analytical expression

Part B: Obtain an expression for the heat flux in the wire as a function of position, x , along the wire.

Part C: Assuming that $k=100 \text{ W/mK}$, $D=0.0025 \text{ m}$, $L=0.20 \text{ m}$, $\dot{q}'''=100 \text{ W/m}^3$, $T_\infty=100^\circ\text{C}$, plot both the temperature distribution and x -component of heat flux from $x=-1\text{m}$ to $x=1\text{m}$. Obtain separate plots for $h=10 \text{ W/m}^2\text{K}$, $h=100 \text{ W/m}^2\text{K}$, $h=500 \text{ W/m}^2\text{K}$.

Problem 2 [Solution]:

A metal rod of length $2d$, diameter D , and thermal conductivity k is inserted into a perfectly insulating wall, exposing one-half of its length to an air stream that is of temperature T_∞ and provides a convection coefficient h at the surface of the rod. An electromagnetic field induces volumetric energy generation at a uniform rate \dot{q}''' (same thing as \dot{q} in the figure below) within the *embedded* portion of the rod.



Write down an expression for the steady state temperature at the base of the exposed half of the rod (T_b). For simplicity, approximate the exposed region as an infinitely long fin.